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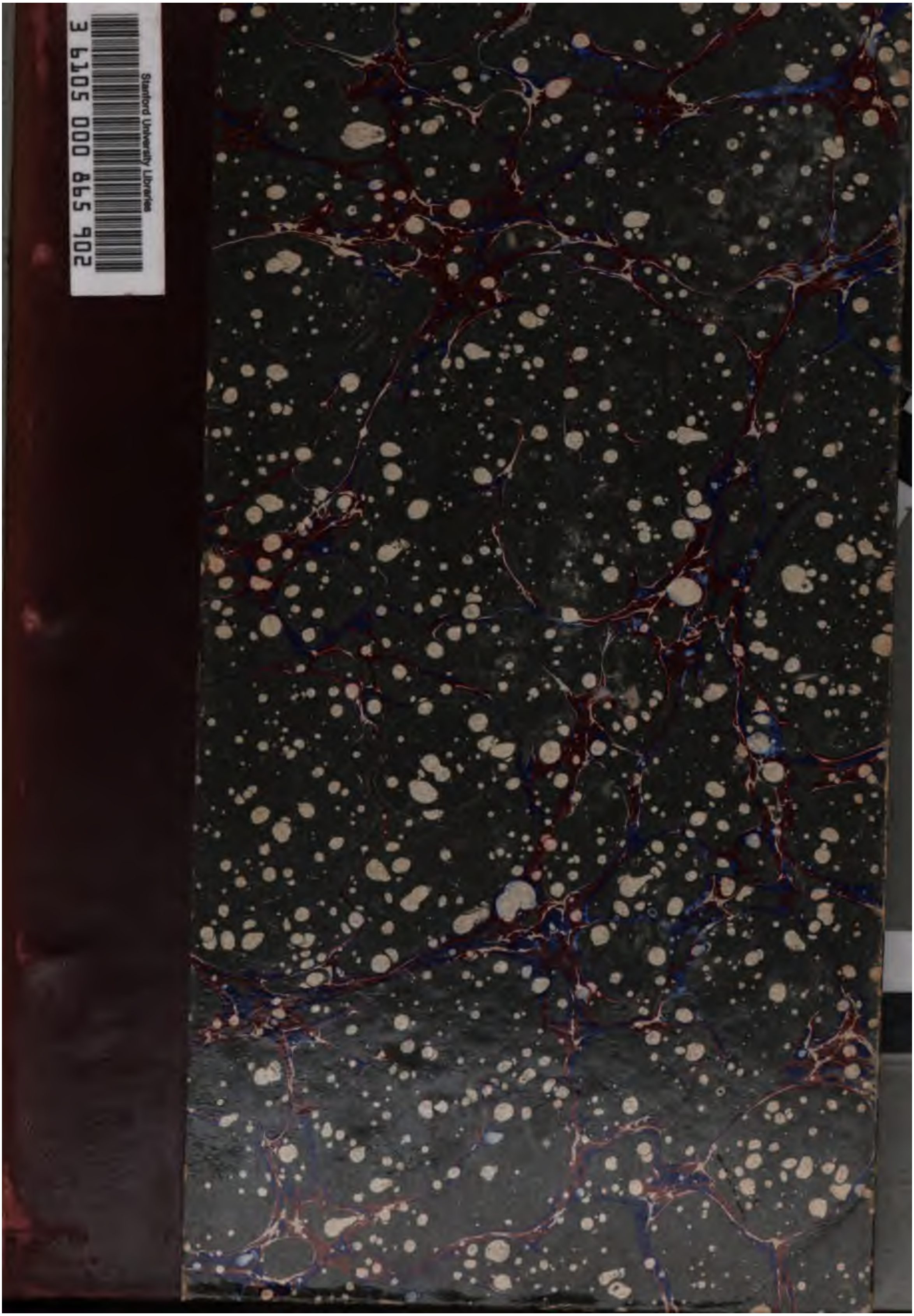

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The Call, San Francisco, California.
The Chronicle, San Francisco, California.
The Examiner, San Francisco, California.
The Mercury, San José, California.
The Record-Union, Sacramento, California.
The Times, Los Angeles, California.
The Tribune, Oakland, California.

THE TOTAL LIGHT OF THE STARS.

By Sidney D. Townley.

While engaged in photometric work at the Lick Observatory during the past summer, a few experiments were made to determine the amount of light received from the sky at night when the Moon is not shining. This work was undertaken at the request of Director Campbell, to whom the problem was suggested by Professor Newcomb. This problem is one to which very little attention has been given, but it is nevertheless one of considerable importance, because it has a direct bearing upon the theories of the structure of the universe. The problem of the structure of the universe, after having lain dormant for nearly a century, is now again commanding the attention of investigators.

Both visual and photographic methods are applicable to the determination of the total amount of light received from the sky, and Professor Newcomb has already employed some of the visual methods, the results of which were printed in the *Astrophysical Journal* (December, 1901). The problem may be divided into two parts: first, to determine the relative brightness of different portions of the sky; and second, to determine, in terms of star-brightness, the amount of light received from a unit of sky-surface in one or more regions of the sky. Professor Newcomb's experiments were performed while spending a summer vacation in the country, where he had at his disposal only some very crude pieces of apparatus. Several methods, which I will not stop to describe, were used by him to determine the relative brightness of different portions of the sky, the conclusion being that the illumination of the Galaxy is about twice that of other portions of the sky. To solve the second part of the problem, Professor Newcomb used a concave spectacle-lens to spread out the light of a star, and then compared this image, reduced by means of dark glass, with an equal area of neighboring sky. Various stars were tried, and it was found that with the particular lens and absorbing-glass used the spread-out image of α *Pegasi* was equal in brightness to the neighboring sky. It will perhaps be sufficient to give the results of these observations, without going into the details of the reductions. The result is that a circle of non-galactic sky one degree in diameter gives 0.9 the light of a star of the fifth magnitude.

My efforts were directed almost exclusively to perfecting a photographic method. The results obtained are meager, but it is believed that a reliable method has been found.

As the light of the sky cannot be concentrated at a point, we must, if we wish to get its value in terms of the light of a star of a certain magnitude, take some means to spread out the light of the star. It was at first thought that this might be accomplished by inserting a photographic plate a few inches behind the focus of a photographic telescope. The Crocker telescope (6 inches aperture and 33 inches focus) was first used for this purpose. A rapid plate (Cramer Crown) was exposed for one hour on *Vega,* about 25 centimeters out of focus. An impression 1.9 centimeters in diameter was formed on the plate, but it was found that the light was very unevenly distributed. The impression was made up of small dark granules surrounded by lighter circles. A straight "gash" ran nearly across the center of the circle, and there were also several smaller curved "gashes." A second plate showed exactly the same pattern, which is due, I suppose, to lack of homogeneity in the glass of the lenses. Similar tests with another lens gave somewhat better results, but not sufficiently good for the purpose. This method had therefore to be abandoned.

The next method tried, and the one adopted, is indeed very simple. Both lenses were removed from the Crocker photographic telescope, and several cardboard diaphragms were made so that they could be attached to the end of the telescope-tube. An exposure of one hour was made upon *Vega* with an aperture of three centimeters, and the result was, of course, an impression on the plate of the size and form of the aperture. Exposures were then made upon the sky for equivalent lengths of time, with apertures ranging from 10 to 15 centimeters. The result should be a nearly uniform darkening all over the plate, which would receive light from an area of the sky the diameter of which would depend upon the aperture used and the distance of the plate from the aperture. If the darkening of one of these plates should be of the same intensity as the impression made by the light of *Vega,* then we would have the very simple relation,—the light received from an area of sky x degrees in diameter is equal in actinic intensity to the light received from *Vega.* After a few experiments, it was seen that the time necessary to get a set of plates—about five hours—could be greatly reduced and the effect of changing atmospheric absorption avoided by making all of the exposures on the sky at the same time. This was accomplished by mounting four camera-boxes, simply aperture and plate-holders, upon a polar axis made of a piece of wood 4×4 inches. In the very limited length of time which I had to devote to this work it was possible to obtain only a few sets of plates. All the plates of each set were, of course, developed at the same time in a large tray. In the exposures a portion of each plate was left covered by the slide in order to measure the effect of any chemical fog which might appear in the development. Several regions of the sky were used, and two stars, *Vega* and *Arcturus.* As *Arcturus* is a yellow star, only a very faint impression was obtained with a one-hour exposure; and as extreme development was necessary to bring out anything, the plates are not to be relied upon.

The intensity of the various plates has been measured by means of an excellent Lummer-Brodhun photometer, kindly placed at my disposal by the Department of Physics of the University of California. It seems hardly necessary to go into details of these measurements. Two sets of plates give, I believe, reliable results, but I am looking upon them all as merely experimental, and hope to continue the work next summer. In the first of these sets four simultaneous exposures of an hour were made upon the region of sky about half-way between γ *Pegasi* and β *Ceti,*—that is, about 40° south galactic latitude. The angular apertures used were 5° 28′.6, 6° 36′.9, 7° 16′.4, 8° 2′.6, and *Vega* was the comparison-star. The photometric measurements show the darkening of the film due to the light of *Vega* to be exactly equivalent to the darkening upon the third plate,—that is, the light from an area of rather vacant non-galactic sky 7° 16′.4 in diameter possesses the same actinic intensity as the light of *Vega.* We will have, therefore, taking the magnitude of *Vega* to be 0.2, the light received from an area one degree in diameter equivalent to the light of a 4.5-magnitude star, which is not far from the result obtained by Professor NEWCOMB, using visual methods,—namely, that the light received from a circle of non-galactic sky one degree in diameter is equivalent to 0.9 the light of a star of the fifth magnitude.

In the second set of plates *Vega* was the comparison-star, and the sky used was a portion of the Milky Way nearest *Vega.* The photometric measurement of these plates gives the light of *Vega* equivalent to that received from an area of galactic sky 5° 19'.8 in diameter. From these two sets we find galactic sky 1.9 times brighter than non-galactic sky, which is also in fair accord with the results obtained by Professor NEWCOMB, but does not agree very well with most persons' general impression of the relative brightness of galactic and non-galactic sky.

As before stated, these results are to be taken as provisional only. It is my intention to carry on the work again next summer, and it is believed that valuable results can now be obtained. I wish to express my obligations to Director CAMPBELL, who kindly placed at my disposal all material and equipment necessary to carry out the experiments.

BERKELEY, CAL., 1902, December 24.

PLANETARY PHENOMENA FOR MARCH AND APRIL, 1903.

BY MALCOLM MCNEILL.

PHASES OF THE MOON, PACIFIC TIME.

First Quarter,	March	6,	$11^h 14^m$ A.M.	First Quarter,	April	4,	$5^h 51^m$ P.M.
Full Moon,	"	13,	4 13 A.M.	Full Moon,	"	11,	4 18 P.M.
Last Quarter,	"	20,	6 8 P.M.	Last Quarter,	"	19,	1 30 P.M.
New Moon,	"	28,	5 26 P.M.	New Moon,	"	27,	5 31 A.M.

The vernal equinox, the time when the Sun crosses the equator from south to north and spring begins, occurs March 21st, 11 A. M., Pacific time.

There will be two eclipses during the period March-April. The first is an annular eclipse of the Sun, on March 28th. The path of the central eclipse begins in middle Asia and runs northwest, ending in the Arctic Ocean north of Alaska. The eclipse may be seen as a partial one in the eastern part of Asia and the northwestern portions of North America. It will not be visible in the United States in general.

The second is a partial eclipse of the Moon on the evening of April 11th. Although the Moon leaves the penumbra at 7 P. M., Pacific time, it leaves the shadow more than an hour earlier; so the eclipse will not be a noticeable phenomenon in the extreme western portions of the country, but it will be well seen in the eastern portions during the early evening. The eclipse is almost total, less than three per cent of the Moon's diameter being uncovered during the middle of the eclipse, which occurs at $7^h\ 13^m$ Eastern time.

Mercury is a morning star during March and until April 10th, when it reaches superior conjunction with the Sun and becomes an evening star. For the first ten days or so of March it rises an hour or more before sunrise, and may be seen in the early morning twilight under good weather conditions. After passing conjunction its distance from the Sun rapidly increases, and toward the end of the month it is well out toward greatest east elongation. It may be seen as an evening star toward the end of the month, and on May 1st it remains above the horizon $1^h\ 40^m$ after sunset.

Venus is an evening star, and increases its distance from the Sun about 16° in their common eastward motion. On March 1st it remains above the horizon a little less than two hours after sunset, and by the end of April this interval has increased to more than three hours, and the planet does not set until nearly 10 P. M. It will be very conspicuous in the western sky in the evening, but not nearly so bright as it is when near inferior conjunction.

Mars will be the most interesting astronomical object during the present period. It comes to opposition on the night of March 28-29th, and during the whole March-April period it remains above the horizon nearly the entire night. It is brighter than it has been since the opposition of February, 1901, or will be again until the spring of 1905. At the time of opposition its distance from the Earth is a little less than sixty millions of miles. On account of the great eccentricity of

Mars's orbit, the nearest approach to the Earth varies greatly at different oppositions. It will be nearer to us by about four million miles at the present opposition than it was at the opposition of 1901; and the oppositions of 1905 and 1907 will will be still better. The motion of the planet among the stars during the two-months period is retrograde about 19°, from a position in *Virgo* not far from *Spica,* the brightest star of the constellation, to a point in *Leo* not far from *Denebola,* the second star of the latter constellation.

Jupiter is a morning star, having passed conjunction with the Sun on February 19th. It rises at about $6^h\ 30^m$ on March 1st, and at about 3 A. M. on April 30th. It is rather too near the Sun to be seen during the early days of March, but soon begins to show in the early morning twilight, and is the brightest object in the eastern part of the morning heavens. It is in conjunction with *Mercury* on the afternoon of March 18th. *Jupiter's* superior brightness will enable it to be seen in the morning twilight, but *Mercury* is so much fainter that it will not be easy to see it in its position, about three Moon's diameters south of *Jupiter.* *Jupiter* is in the constellation *Aquarius,* and moves 13° eastward and northward during March and April.

Saturn is also a morning star, and rises at about 5 o'clock on March 1st. By the end of April it rises shortly after 1 o'clock. As it is much less bright than *Jupiter,* it is not very conspicuous during the early days of March. It is in the constellation *Capricorn,* and during the two-months period moves about 5° eastward and northward.

Uranus rises at about half-past 2 o'clock on March 1st, and at about half after 10 at the end of April. It moves slowly eastward among the stars during March, and then retrogrades during April; but the whole motion is confined to a space about equal to the Moon's diameter. It is still in the southern extension of *Ophiuchus,* and no bright star is near enough to afford an easy means of identification.

Neptune is in *Gemini.* By the end of April it sets at about 11 P. M.

(FORTY-FIRST) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to WILLIAM R. BROOKS, Director of Smith Observatory, Geneva, New York, for his discovery of an unexpected comet on April 14, 1902.

The Committee on the Comet-Medal:
W. W. CAMPBELL,
CHAS. BURCKHALTER,
WM. M. PIERSON.

(FORTY-SECOND) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to Professor CHARLES D. PERRINE, of the Lick Observatory, for his discovery of an unexpected comet on September 1, 1902.

The Committee on the Comet Medal:
W. W. CAMPBELL,
CHAS. BURCKHALTER,
WM. M. PIERSON.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

NEW SPECTROSCOPIC BINARY STARS.

During the absence of Dr. CAMPBELL from the Observatory a few results of interest have been obtained in the work with the Mills spectrograph. Three new spectroscopic binaries have been discovered,—viz., ν *Andromedæ*, π^4 *Orionis*, and σ *Geminorum*.

The first of these, ν *Andromedæ*, has very few lines in that part of the spectrum which we use, and the hydrogen line whose wave-length is 4340.634 is quite diffuse; but there are a few lines due to helium and magnesium which allow fairly accurate measurements. The radial velocity was —17 kilometers per second on October 8, 1902, —76 kilometers on November 5th, and + 49 kilometers on January 14, 1903, giving a total range of 125 kilometers.

The star π^4 *Orionis* has a spectrum very similar to that of ν *Andromedæ*, but the range of velocity which we have obtained is not so great, though it is too large to allow any doubt of the star being a binary. The velocity was + 43 kilometers on October 6, 1902, ± 0 on January 4, 1903, and + 6 on January 12th.

The spectrum of σ *Geminorum* shows a great number of metallic lines, though they are in most cases rather ill-defined, so that measurements of its velocity are not so accurate as is the case with most stars whose spectra show numerous lines. The rather rough preliminary measurements that have been made show such a range of velocity, however, that the star is certainly a binary. On March 16, 1902, its velocity was approximately + 74 kilometers, against + 12 kilometers on January 12th and + 9 on January 13, 1903.

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* Lick Astronomical Department of the University of California.

Another star, ϕ_2 *Orionis,* is interesting on account of its great radial velocity. Approximate measurements give + 96 kilometers on October 28, 1902, + 103 on November 24th, and + 98 on December 30th. It is not likely that the range of seven kilometers in these measurements indicates a real variability in the velocity of the star, for the plate of November 24th was taken under poor conditions and was very much under-exposed.

Approximate measurements of the plates of the spectrum of τ *Ursæ Majoris,* taken on January 22, 1900, and April 15, 1902, respectively, showed a range of five kilometers. As this was sufficient to cause suspicion of variability, Mr. STEBBINS measured both plates very carefully, and obtained the velocities — 3.8 kilometers for the first date and — 10.2 for the second, showing that the star is almost certainly a binary. A rough measurement of a later plate gives a velocity of — 4 kilometers (on December 29, 1902).

Most of the measurements of the other plates were made by Dr. H. D. CURTIS, and many of the plates were exposed by him.

H. M. REESE.

THE DIAMETER OF *TITAN*.

The statement is sometimes made in books on astronomy that the diameter of *Titan* is probably 3,000 to 4,000 miles. These values are undoubtedly too large. When the micrometer-wires of the 36-inch refractor are separated to an amount corresponding to a diameter of 4,000 miles and the image of *Titan* is placed between them, this image, when the atmospheric conditions are sufficiently good to stand very high powers, will easily be seen to be entirely inside the inner edges of both wires. When the wires are separated to correspond to a diameter of three thousand miles the image is very nearly tangent to the inner edges of both wires, from which it may be inferred that the diameter is certainly less than 3,000 miles.

During the past opposition, while measuring the relative positions of the satellites of *Saturn,* I have on several nights satisfied myself respecting the correctness of the above statements. On two nights when the seeing was particularly good I have also measured the apparent diameter of *Titan,* with the following results:—

1902, June	19	0″.60 or 2,473 miles
October	2	0 .53 or 2,332 miles

The first of these measures was made under excellent atmospheric conditions. A power of 2400 was used, and even with this very high power *Titan* presented a sharply defined disk. It is seldom that so high a power can be used for such work. The second measure was made with a power of 1000. For so small a distance this is about the minimum power that can be used to advantage.

On five nights in each of the years 1894 and 1895 Professor BARNARD measured the diameter of *Titan* with the large refractor of the Lick Observatory. His separate results, given in arc, when reduced to miles, range from about 2,100 to nearly 3,200 miles. The mean result which he obtains for the two years is 2,720 miles.

If we say that the diameter of *Titan* is about 2,500 miles we shall probably not be very much in error.

January 15, 1903. W. J. HUSSEY.

A NEW DOUBLE STAR = A. B. of Σ 1233.

Observations made with the 36-inch telescope show that the principal component of the wide pair Σ 1233 is itself a close double star. Measures were made on two nights as follows:—

AB (NEW).

1903.026	59°.9	0″.26	7.5–7.5	1000, 3
.040	62 .9	0 .24	7.5–7.5	1500, 3
1903.03	61°.4	0″.25	7.5–7.5	

AB and C = Σ 1233.

1903.026	328°.8	18″.21	7.0–11.0	520, 3
.040	328 .9	18 .11	7.0–11.0	520, 3
1903.03	328°.8	18″.16	7.0–11.00	

STRUVE's measure of the wide pair is:—

1828.71	331°.5	18″.20	7.2–11.5

The star's approximate place for 1880.0 is R. A. 8^h $21^m.9$; Decl. — 2° 4′. R. G. AITKEN.

January 16, 1903.

PHOTOGRAPHIC OBSERVATIONS OF MINOR PLANETS.

Asteroids (415) *Palatia* and (439) *Ohio* were picked up by trails on negatives of forty minutes' exposure with the Crossley reflector on the night of June 23, 1902. On the same night Mr. PALMER and I secured four five-minute exposures on each asteroid. On the following night, Mr. PERRINE and I exposed two more plates on each object. Two exposures were made on each negative, the plate being moved in Right Ascension between successive exposures. In the reductions, the exposures on each plate were treated as so many comparisons in a micrometer observation, except in case of Plate 6, on which but one of the asteroid images was available for measurement. The measures have been corrected for refraction, scale value, and orientation. Mean places of the comparison-stars for 1902.0 were employed directly in the reduction, as precession and aberration simply affect the orientation.

The accompanying table contains the positions of the asteroids as determined from each plate and a comparison with ephemerides kindly furnished by Dr. E. F. CODDINGTON. The details of the measures will be published in the Lick Observatory *Bulletin*. In every case, the asteroid images were measured with some difficulty but more particularly was this true of the negatives of June 23d, when the seeing was poor.

R. H. CURTISS.

Plate.	Mt. Hamilton M.T.	α	δ	log $p\Delta$		O − C		Exposure Time.
				α	δ	Δα	Δδ	
	(439) Ohio.							
	1902 h m s	h m s	° ′ ″			m s	′ ″	m
1	June 23 12 32 58	17 18 32.87	+0 34 0.8	9.211	0.722	+0 56 16	+2 10.1	5
2	23 12 46 55	17 18 32.44	+0 34 1.4	9.277	0.722	+0 56.15	+2 10.0	5
3	24 10 34 45	17 17 53.51	+0 34 58.9	n8.826	0.728	+0 56 19	+2 9.8	5
4	24 10 47 45	17 17 53.08	+0 34 59.3	n8.613	0.728	+0 56 16	+2 9.7	5
	(415) Palatia.							
5	June 23 10 56 55	15 33 51.63	−9 22 31.9	9.256	0.801	−0 35 25	+2 6.6	5
6	23 11 18 55	15 33 51.18	−9 22 32.6	9.346	0.798	−0 35.21	+2 6.6	5
7	24 9 32 45	15 33 23.00	−9 23 9.1	8.307	0.807	−0 35.11	+2 6.5	8
8	24 9 49 45	15 33 22.63	−9 23 9.7	8.437	0.807	−0 35.13	+2 6.4	8

THE COMETS OF THE YEAR 1902.

The year that has just closed will not be remembered as a remarkable one in the annals of cometary discovery, though PERRINE's comet (1902 *b*) proved to be the brightest one of recent years. Several periodic comets returned to the neighborhood of the Sun during the year, but all of them escaped detection, though they were searched for carefully, both visually and photographically. The four comets recorded were all unexpected ones, and two of them have added nothing to our knowledge of these bodies.

Comet *a*, discovered by Dr. BROOKS on April 14, 1902, was not announced until confirmed on the following night. Observations of it were secured at various stations in this country and in Europe on the nights of April 16th, 17th, 18th, and 19th; but, so far as I know, no one has seen it since then. Cloudy weather prevented observations here after April 16th, though the comet was seen for a few moments on the 17th. It was a morning object when discovered and was rapidly approaching the Sun, and its orbit was such that its apparent position in the heavens was very near that of the Sun for several months. After passing the Sun, the comet was looked for here in the positions predicted by the parabolic elements, and in those derived from LEUSCHNER's short-period ellipse, but it was not seen.

Comet *b*, discovered by PERRINE in the early morning of September 1, 1902, has been described at length in Nos. 86 and 87 of these *Publications*. The last observation secured here before the comet passed the Sun was made on November 17th. At present it is too far south to be observed from stations in the northern hemisphere, but it will again be in reach by the middle of February, and, if it is as bright as theory predicts, it should be for several months an easy object to observe.

It was announced in the *Astronomische Nachrichten*, and in the *Monthly Notices*, R. A. S., in September that Mr. JOHN GRIGG, of Thames, New Zealand, had discovered a faint comet on the 22d of July. Mr. GRIGG's letter states that he secured approximate measures of the comet's position on the nights of July 23d, 26th, 29th, and August 1st and 2d. Since then he has not seen it, and so far no evidence is at hand that it has been seen by any one else. Dr. KREUTZ communicated an ephemeris based on approximate elements computed by Mr. GRIGG, and the comet was looked for here on several nights without success. This object has been designated Comet *c* 1902.

The last comet of the year was discovered by M. GIACOBINI at Nice on December 2, 1902. The telegram announcing discovery reached us on December 4th, but clouds prevented observations until the following night. Since then measures have been made on a number of nights, the last being secured on January 7th. The comet is very small,—only 2′ or 3′ in diameter,—and quite faint, but possesses a well-defined nucleus of about the same brightness as a 13½-magnitude star. Its apparent motion is very slow, for it is still several months distant from perihelion, and only half a dozen known comets have a perihelion distance as great as that assigned to this one by the preliminary elements. For this reason it is not likely to be at all conspicuous, even when observed with a good telescope; but, from the situation of its apparent path through the sky, it is probable that its motion can be observed for a long time and data secured for an accurate orbit.

R. G. AITKEN.

Jan. 10, 1903.

THE SPECTRUM OF THE FAINT NEBULOSITY AROUND *NOVA PERSEI*.*

The anomalous changes which have been observed in the faint nebulosity surrounding *Nova Persei* made it highly desirable to obtain as great a variety of evidence as possible, particularly in the way of physical observations. In March, 1902, observations were secured with the Crossley reflector tending to show that there was little or no polarization in the light from the brightest of the condensations then visible.

The nebulosity was too faint to attempt any spectroscopic observations with the apparatus available. A slit-spectrograph having a quartz prism and quartz lenses was designed especially for this problem, to be used in connection with the Crossley reflector. The dispersion was purposely made very small.

A negative was secured on the nights of October 31st and November 1st, 2d, and 4th, with a total exposure of over 34 hours.

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* Abstract of L. O. *Bulletin*, No. —.

The slit of the spectrograph was placed across the brightest portion of Condensation D.

The resulting negative showed a very faint spectrum, which, after careful consideration and some experiments, was deemed to be that of the nebulosity. So far as can be told from such small dispersion and intensity, the spectrum is continuous, with the greater portion of the light condensed in a band between H_β and H_γ. This band is strongest just above H_β and from this point fades gradually until it is entirely lost in the H and K calcium region. Beyond this point, up in the ultra-violet region, there is a very slight increase of strength again.

It is suspected that in one or two cases there may be traces of bright lines, but the whole spectrum is so faint as to preclude any definite deduction on this point.

The above observation shows that the spectrum of this mass of nebulosity is not the ordinary bright-line spectrum of the nebulæ. The spectrum observed may correspond to that of the *Nova* at some epoch in its recent history, although that seems doubtful, from the fact that since July, 1901, (at least,) practically all the light of the *Nova* has been confined to a few lines. The faintness of the spectrum of the nebulosity makes it difficult to decide this point. C. D. PERRINE.

1903, January 13.

RED SUNSETS AT MT. HAMILTON.

Since the outburst of Mont Pelée in May last, the sunsets have been watched to see if there would be any such effects as were observed after the Krakatoa eruption of 1883. An augmentation of color was suspected in August and September, but as there was considerable smoke from forest fires in the lower atmosphere at that time, it was thought that that might be the cause. For several weeks past the atmosphere has been very transparent, owing to frequent rains and fogs, and favorable, therefore, for the detection of any unusual color due to dust in the upper atmosphere.

On many cloudless evenings a very perceptible deepening of color has been observed. The band near the horizon has been of a very deep crimson, and some color has usually been visible almost to the zenith. The tints are very clear and pure, much more so that those usually resulting from smoke in the lower atmosphere. On several occasions the morning sky has shown some such effect, but much less marked than in the evening.

The recent sunsets are in no way comparable with the magnificent effects of 1883.

It is not possible to connect these appearances with certainty with the Martinique eruption or that in Guatemala. The surface currents in the atmosphere are contrary in both cases. Unless the matter was brought by reverse currents in the high atmosphere, it must have traveled almost around the globe. It is impossible, for reasons given above, to trace a relation by means of time.

C. D. P.

1903, January 10.

GRANT FROM THE CARNEGIE INSTITUTION.

The Carnegie Institution has made a grant of $4,000 to the Lick Observatory for the present fiscal year of the Institution, to be expended in the employment of assistants and computers.

W. W. CAMPBELL.

ELEMENTS OF COMET *d* 1902.

From my observations of December 5 and December 30, 1902, and January 17, 1903, I have computed the following set of parabolic elements of Comet *d* 1902:—

$$T = 1903,\ \text{March}\ 23.27958\ \text{G. M.T.}$$

$$\left.\begin{array}{rrrr} \omega = & 5^\circ & 45' & 4''.4 \\ \Omega = & 117 & 28 & 0\ .0 \\ i = & 43 & 53 & 57\ .9 \end{array}\right\}\ 1903.0$$

$$\log q = 0.443156$$

Residuals (O - C):—

$$\Delta\lambda' \cos\beta' = -3''.6\,;\quad \Delta\beta' = -3''.1$$

Constants for the Equator of 1903.0:—

$$\begin{array}{l} X = r\ [9.896716]\ \sin\ (221^\circ\ 33'\ 31''.7 + v) \\ Y = r\ [9.999990]\ \sin\ (131\ \ 15\ \ 44\ .4 + v) \\ Z = r\ [9.789065]\ \sin\ (\ 40\ \ 46\ \ 31\ .3 + v) \end{array}$$

R. G. AITKEN.

ASTRONOMICAL TELEGRAMS.

(Translations.)

CAMBRIDGE, Mass. Dec. 4, 1902.

To Lick Observatory: (Received 8:05 P.M.)

Kiel cables that a faint comet was discovered by GIACOBINI at Nice on December 2.396 G. M. T., approximately in the position R. A. 7^h 17^m 40^s; Decl. — 1° 58′. Direction of motion, northwest. (Signed) E. C. PICKERING.

CAMBRIDGE, Mass. Dec. 4, 1902.

To Lick Observatory: (Received 8:35 P.M.)

Comet Giacobini was observed by DINWIDDIE at Washington on December 3.737 G. M. T., in R. A. 7^h 17^m 24^s; Decl. — 1° 50′. The position is approximate.

(Signed) JOHN RITCHIE, JR.

MT. HAMILTON, CAL., Dec. 6, 1902.

To Harvard College Observatory: (Sent 9:55 A.M.)
To Students' Observatory, Berkeley, Cal.:

Comet Giacobini was observed by AITKEN on December 5.9848 G. M. T., in R. A. 7^h 16^m $45^s.7$; Decl. — 1° 31′ 2″.

(Signed) R. H. TUCKER, in charge.

MT. HAMILTON, CAL., Dec. 8, 1902.

To Harvard College Observatory: (Sent 9:45 A.M.)
To Students' Observatory, Berkeley, Cal.:

Comet Giacobini was observed by AITKEN on December 6.7930 G. M. T. in R. A. 7^h 16^m $30^s.7$; Decl. — 1° 23′ 49″; and on December 7.8192 G. M. T., in R. A. 7^h 16^m $9^s.8$; Decl. — 1° 14′ 30″. (Signed) R. H. TUCKER, in charge.

BOSTON, MASS., Dec. 15, 1902.

Elements and ephemeris of Comet Giacobini were computed at Washington as follows:—

$$\begin{aligned} T &= 1903\text{, April } 1.7863\text{, G. M. T.} \\ \omega &= 9^\circ\ 47'\ 7'' \\ \Omega &= 117\ \ 12\ \ 35 \\ i &= 43\ \ 53\ \ 29 \end{aligned} \left.\vphantom{\begin{aligned}a\\a\\a\end{aligned}}\right\} \text{Mean equator of } 1902.0$$

Natural $q = 2.686$

(Signed) JOHN RITCHIE, JR.

[The ephemeris at 4-day intervals to December 29 is here omitted.]

REPORTS OF OBSERVATORIES.

The annual publication in one place of brief reports upon astronomical researches made in this country would seem to be desirable. Those desiring to prepare such reports are requested to forward manuscript to FRANK SCHLESINGER, International Latitude Observatory, Ukiah, California.

NAVAL OBSERVATORY, WASHINGTON, D. C.

During the year the following changes have taken place in the personnel:—

Professors of Mathematics THOS. J. J. SEE and MILTON UPDEGRAFF were detached from the Observatory on September 20, 1902, and ordered to duty as instructors in the Department of Mathematics at the United States Naval Academy, where their services were urgently required, owing to the great scarcity of line officers in the navy who had formerly done this work.

November 1, 1902, Captain CHAS. H. DAVIS, U. S. N., was relieved as Superintendent by Captain COLBY M. CHESTER, U. S. N.

The instruments have been used as follows:—

The 6-inch transit-circle has been devoted to routine observations of the Sun, Moon, and planets, together with the special lists of heliometer comparison-stars issued by Sir DAVID GILL.

The 9-inch transit-circle has been undergoing repairs and improvements.

The prime vertical transit instrument has been devoted to observations for the determination of aberration, nutation, and variation of latitude, and to the determination of the Declinations of 390 miscellaneous stars.

The alt-azimuth instrument has been devoted to a determination of the latitude of the Observatory and the Declinations of 350 standard stars.

Photographs of the Sun have been obtained with the photoheliograph on every clear day.

The equatorials have been devoted to measurements of the diameters of the planets, to observations of their satellites, to observations of asteroids, comets, occultations, and variable stars.

During the year volume II, Publications of the U. S. Naval Observatory, Second Series, containing the observations of the

Astronomische Gesellschaft Zone — 13° 50′ to — 18° 10′ has been issued, and volume III is in press.

The formation of the catalogue from the observations in volume II is in progress, and some work has been done on cataloguing the Washington Zones 1846 to 1852.

A very important part of the work of the Observatory consists in the inspection, purchase, care, and issue of chronometers, watches, sextants, octants, telescopes, binoculars, and surveying and photographic outfits, including all nautical instruments except compasses. The regular annual trial of chronometers includes about one hundred chronometers, of a value of about $30,000, and lasts six months. The time service, maintained in connection with the chronometer service, sends out daily, except Sundays and holidays, telegraphic noon-signals that reach all points of the country, correcting some 40,000 clocks and dropping sixteen time-balls.

The following articles from members of the Observatory staff have appeared during the year: The Naval Observatory Eclipse Expedition to Sumatra, by A. N. SKINNER, (*Popular Astronomy,* January, 1902); Observations of the Diameters of the Satellites of *Jupiter* and of *Titan,* the Principal Satellite of *Saturn* (observations by daylight), by T. J. J. SEE, (*A. N.,* No. 3764); Micrometrical Measures of the Equatorial Diameter of *Saturn* and of his System of Rings (observations by daylight), by T. J. J. SEE, (*A. N.,* No. 3768); Micrometrical Measures of the Diameter of *Uranus* (observations by daylight), by T. J. J. SEE, (*A. N.,* No. 3768); Observations of the Satellites of *Saturn* and *Uranus,* by T. J. J. SEE, (*A. N.,* No. 3806); Observations of Heliometer Comparison-Stars, by M. UPDEGRAFF and J. C. HAMMOND, (*A. J.,* No. 528); Micrometric Measures of Double Stars, by E. A. BOEGER, (*A. J.,* No. 522); Observations of (26) *Proserpina,* by G. K. LAWTON, (*A. N.,* No. 3786); Some Results of the Total Eclipse in Sumatra, of May 18, 1901, obtained with the Photoheliograph, at Fort de Kock, by G. H. PETERS, (*Astrophysical Journal,* September, 1902); Elements and Ephemeris of Comet 1902 *d,* by H. R. MORGAN and C. W. FREDERICK, (*A. J.,* No. 528); A Device for Conducting Electric Circuits to the Eye-end of the Equatorial Telescope, by W. W. DINWIDDIE, (*Popular Astronomy,* June, 1902); Observations of Comet 1902 *d,* by W. W. DINWIDDIE and C. W. FREDERICK, (*A. J.*, No. 528); Observations of Comet 1902 *d*, by W. W. DINWIDDIE, (*A. J.*, No. 528).

C. M. CHESTER, *Captain, U. S. N.,*
Superintendent Naval Observatory.

January 12, 1903

OBSERVATORY OF THE UNIVERSITY OF MINNESOTA.

The research work of the Observatory has been confined almost exclusively to measurement and reduction of the series of *Eros* photographs made during the winter of 1900. In taking these photographs the plan followed was to make all the exposures of a single night on the same plate; so when one plate is worked up the work of that night is finished. Exposures were made at as great hour-angles as possible, so that the Sun's parallax might be obtained by the morning and evening method. This plan was successfully carried through on about fifteen nights, and only partially so on some thirty-five nights.

Twenty-one of the most perfect plates have been measured. They contain on an average about twelve exposures and thirteen reduction-stars. A number of filar micrometer comparison-stars were also measured, that their positions might be accurately determined. Many of the stars, however, were too faint to be photographed. Three of the plates have been provisionally reduced and the Sun's parallax computed.

From these the probable error of the position of an image, in one equation of condition, is about one tenth of a second. The probable error of the Sun's parallax, of course, will depend on the hour-angles at which the exposures were taken and the resulting parallax factor. In one of the above cases the factor is 20, making the probable error of the Sun's parallax from the night's work about 0″.02.

Some difficulty has been experienced in making the measurements on account of bad images near the edge of the plates. They are usually round and well defined near the center. But half-way out from the center they begin to develop comet-like tails. These tails I afterward found may be almost completely eliminated by capping the object-glass down from its full aperture 10½ inches to 9 inches. This is accomplished also without materially weakening the intensity of the images.

The results of the preliminary reductions lead me to believe that the final reduction of the whole series of photographs will be reasonably accurate.

January 1, 1903. F. P. LEAVENWORTH.

VASSAR COLLEGE OBSERVATORY.

PROFESSOR MARY W. WHITNEY, DIRECTOR.

1. Publications of Vassar College Observatory during 1902: Observations of *Nova Persei*, by MARY W. WHITNEY and CAROLINE E. FURNESS (*Ast. Nach.*, 3757); Observations of Minor Planets, by MARY W. WHITNEY and CAROLINE E. FURNESS (*Ast. Jour.*, 517); Ditto, ditto (*Ast. Nach.*, 3795); Observations of Comet *b*, 1902, (PERRINE), by MARY W. WHITNEY and CAROLINE E. FURNESS (*Ast. Jour.*, 528); Prediction of maxima and minima of variable stars of long period for 1902, by IDA WATSON and HELEN SWARTZ, graduate students in Astronomy (published monthly in *Pop. Ast.* for 1902); the variable star *U Cephei*, by IDA WATSON (*Pop. Ast.*, June, 1902).

2. Observations of minor planets and comets are being made continuously though somewhat irregularly. There are now on hand, in various stages of reduction, about thirty observations of *Eros* and the same number of observations of minor planets.

3. During the past year, Miss COWLEY, a graduate student, was engaged in computing the definitive orbit of Comet 1826 II. A portion of the work—viz., the determination of the Right Ascensions and Declinations and proper motions of the comparison-stars—has already been completed, and was accepted as a thesis for the A. M. degree at Vassar College.

The most important work carried on is the measurement and reduction of photographic plates, a continuation of the work included in *Publications* I of the Observatory. Of the eight plates covering the region 88° to 89°, six have been measured and partially reduced. For the remaining measurement and the completion of the reduction the Observatory has received from the Carnegie Institution a grant of $1,000, to enable us to finish the work in a year's time. The money will be expended in employing additional computers, since a large portion of the time of the director and the assistant is given to instruction.

POUGHKEEPSIE, January 6, 1903.

ASTRONOMICAL OPERATIONS OF THE U. S. COAST AND GEODETIC SURVEY.

In the main portion of the United States the only astronomical observations were at Tonopah, Nevada, the latitude and longitude being determined, and at Iron Mountain Furnace Tract, Tenn., latitude only. In Alaska the latitude and longitude of a point on St. Lawrence Island and of a point on Nunivak Island were determined, the longitudes being observed by the chronometric method. No astronomical observations were made in Hawaii or in Porto Rico.

In the Philippines the latitudes of twenty-nine stations have been determined. The longitudes of twenty-eight stations have also been determined with reference to Manila, of which the longitude had previously been determined through the cable; and azimuths were observed at twenty-three stations. Of the twenty-eight longitudes in the Philippines, twenty-seven were determined by the telegraphic method and one by the chronometric method. The figures given above for the Philippines include all stations from which any reports have reached the Washington Office up to this date, and include observations in both 1901 and 1902.

F. W. PERKINS, *Acting Superintendent.*

Jannary 9, 1903.

HARVARD COLLEGE OBSERVATORY.*

East Equatorial.—The observations with this instrument have been made by Professor O. C. WENDELL, and have been of the same general character as in previous years. Seventeen thousand photometric light comparisons have been made, principally with the polarizing photometer with achromatic prisms. With this photometer 1,024 comparisons were made of *X Cancri*, 992 of *U Cephei*, 960 of *U Sagittæ*, 944 of *U Scuti*, 880 of 78.1901 *Cygni*, 800 of *R Ursæ Minoris*, 752 of *β Persei*, 736 of *χ Cygni*, 528 of *β Lyræ*, 480 of *W Delphini*, 448 of *U Ophiuchi*, 416 of $+43°$ 4101, recently discovered here, 384 of *Nova Persei*, No. 2, 320 of *X Persei*, 192 of *R R Lyræ*, 160 of *S W Cygni,* 160 of standard stars in the cluster *Messier* 15, 144 of *Y Cygni,* 96 of *R Coronæ,* 96 of *SS Cygni,* 64 of *T Cygni,* 64 of *T Persei,* 64 of *μ Herculis,* 48 of *R Lyræ,* and 32 each of *U Geminorum, X Herculis,* d *Serpentis, μ Cephei,* and *X Virginis.* In addition to the above, 1,984 comparisons were made of *o Ceti,* 288 of *U Camelopardalis,* and 1,968 of double stars, with a second photometer adapted to the comparison of stars too near together to be measured with the first instrument. The same instrument has been used in the photometric measurement of *Jupiter's* satellites while undergoing eclipse. Seventeen eclipses have been observed, making the total number 736. Photometric observations of comparison-stars for variables have also been continued, the number of settings being 192. The systematic observation of variable stars of long period throughout their changes, and the reduction of the results to the scale of the meridian photometer have been continued. Two hundred and fifty estimates by the method of ARGELANDER have been made, generally when the stars were too faint to be observed with small instruments. The selection of fourteenth magnitude standards has been continued. Several other objects of a miscellaneous character have also been observed.

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* Extracted, with Professor PICKERING'S permission, from the *Fifty-seventh Annual Report of the Director of the Astronomical Observatory of Harvard College for the year ending September 30, 1902.*

Similar observations of variables and comparison-stars have been made with the West equatorial. With it 1,130 estimates of variables, and 235 estimates of comparison-stars have been made by Miss CANNON, 3,324 estimates of variables, and 170 estimates of comparison-stars have been made by Mr. CAMPBELL, with the naked eye, field-glass, and a 5-inch portable telescope. Three hundred and ninety-one estimates of variables have been made by Mr. COLSON, and 326 by Mr. WHITE. Nine hundred and eighty-one estimates of variables have been made by Mr. F. E. SEAGRAVE, of Providence, and communicated by him to this Observatory. Observations of variable stars have also been communicated by six other persons.

Meridian-Circle.—The principal use of this instrument during the year has been the determination of clock error, but on 20 dates observations of *Nova Persei,* No. 2, or faint stars in its vicinity, were made by Mr. DUNNE. The total number of transits, including those of circumpolar and almanac stars required for the reduction of the observations was 218. On 10 other dates observations were made with wire screens, in order to furnish an independent determination of personal equation with respect to magnitude. These observations have not yet been reduced. The power of the instrument in exhibiting faint stars was compared with that of the four-inch transit-circle of the Students' Astronomical Laboratory, by a short series of observations in June, 1902, from which it appeared, as had been previously thought, that the 8-inch object-glass of the meridian circle was less efficient than would be supposed from its size.

The reduction of the observations of stars in the zone — 9° 50′ to — 14° 10′ has proceeded so far that the results in Right Ascension and Declination for 1900.0 are now very nearly complete, and are collected in readiness for the computation of the mean result for each star. But it is expected that cases of large discrepancy, especially in the observations of the years 1896 to 1898, will be found to require a second reduction, and that entire zones may need small corrections when the residuals of the separate observations have been obtained for the zone journal. The work of collecting the estimates of magnitude is also largely completed, and the preparation for publication, both of the final catalogue and of the zone journal, has been begun.

The reduction of the observations made by the late Professor ROGERS, during the years 1879 to 1883, has been continued by Miss S. C. BOND under the supervision of Miss ANNA WINLOCK. The computation of the reductions from apparent to mean place at intervals of ten days for all the stars observed is now complete. About 3,000 reductions for single observations have been obtained by interpolation from these computations, and about as many more remain to be obtained.

12-inch Meridian Photometer.—With this instrument 66,932 settings have been made by the Director on 118 nights. In all, 265,604 settings have been made in four years. The principal work has been the extension of the photometric scale from the tenth to the thirteenth magnitude. Sequences of stars have been selected and measured for all the regions contained in Series I, II, and III, of HAGEN's Catalogues, from the magnitude 7.5 to 12.5, and in Series IV, from 7.5 to 10.5.

Meridian Photometer.—With this instrument 10,784 measures were made by Professor BAILEY on 30 nights, from

October 1, 1901, to April 18, 1902. It was then dismounted and sent to Peru, where he obtained 7,804 settings on 18 nights, from July 10 to September 30, 1902. The principal objects observed were a series of stars of about the fifth magnitude, one in every region 10° square. Each star was to be observed twice on ten nights, taking various precautions so that the resulting magnitudes should furnish accurate standards of photometric magnitude, from the north to the south pole. Various miscellaneous objects, including comparison-stars for *Eros, Iapetus,* and variables, were also measured. The total number of settings so far obtained with this instrument is 1,051,768.

Henry Draper Memorial.—Since its establishment in 1886, the Henry Draper Memorial has developed three new and unique lines of work. *First,* by the substitution of the objective prism and doublet for the slit spectroscope and single lens, the spectra of large numbers of stars are photographed simultaneously by the former, instead of singly by the latter method. These photographs have been repeated until every portion of the sky has been covered, using the 8-inch Draper telescope for the northern stars, and the Bache telescope, an 8-inch doublet of similar construction, for the southern stars. As a result, we have a photograph of the spectrum of every star in the sky permanently brighter than the ninth or tenth magnitude, besides many thousands that are fainter. These plates have been carefully examined by Mrs. FLEMING, with the result that large numbers of objects having peculiar spectra have been discovered. The number of such objects found elsewhere is small, and it is probable that all that are bright have been found from these plates, thus making this part of the work complete. We are now extending it to the fainter stars, using smaller dispersions and longer exposures. There are two classes of stars that can only be studied by frequent photographs like those described above. Of the eight *Novæ* which are known to have appeared during the last sixteen years, two were bright and visible to the naked eye. All of the others were found from the Draper photographs, and would probably otherwise never have been discovered. Variable stars of long period have very peculiar spectra, which differ greatly from one another, and can generally be photographed only when they are bright. Nearly two hundred of these objects have been discovered from the Draper photographs. *Secondly,* by placing large objective prisms in front of the 11-inch Draper telescope, stellar spectra six inches long and showing several hundred lines have been obtained. Shorter spectra were obtained of the fainter stars, and from them a detailed study of 681 of the brighter stars visible in Cambridge was made by Miss MAURY. A similar study of 1,122 southern stars photographed with the 13-inch Boyden telescope has been made by Miss CANNON. Although the stars have thus been arranged in a logical sequence, the object was rather to show that large numbers of stars had identical spectra, and then to publish all the facts regarding a typical star of each group. All the material is thus furnished to any future investigator, so that he may continue his studies without having recourse to these or other photographs. The discovery of spectroscopic binaries, of stars having the hydrogen lines bright and variable, and of a new series of hydrogen lines, resulted from these investigations. The third field of work is perhaps the most important of all. By photographing repeatedly all portions of the northern sky with the 8-inch Draper telescope, and of the southern sky with the Bache telescope, we have a map of the entire sky showing all the brighter stars night after night. This furnishes a complete history of the heavens for every year since 1890, and a partial history since 1886. When any new object is discovered, we can trace its motion or variations in brightness, throughout this period from these photographs. As no such collection of photographs has been made elsewhere, the importance of properly caring for it, and continuing it, is obvious. An additional force of assistants is much needed to study these plates, and thus determine the past history of known objects, and of new ones as fast as they are discovered.

The number of photographs taken with the 11-inch Draper telescope is 475, making 14,020 in all with this instrument; with the 8-inch Draper telescope, 1,642, making in all 29,298. The total number of photographs of the stars taken at Cambridge during the year is 4,254. Fifteen eclipses of *Jupiter's* satellites, and ten occultations, have been successfully photographed with the 11-inch Draper telescope. Four variable stars have been found by Mrs. FLEMING from an examination of the Draper photographs. One of these, + 43° 4101, proved to be an *Algol* variable with a period of 30 days, and duration of obscuration 2 days. This period is much longer than that of any other *Algol* star as yet discovered, the next longest period being that of *S Cancri,* which is 9.5 days. The other three were found from the presence of bright hydrogen lines in their spectra. One of these, whose position for 1900 is R. A. = $12^h\ 50^m.7$, Dec. = —57° 21′, has a peculiar spectrum. A fifth variable, + 40° 4390, found by Mr. J. A. DUNNE with the meridian-circle, was confirmed by the Draper photographs.

The general plan of taking the photographs, as described in the last report, has been maintained under the direction of Mr. KING. The illumination of the sky by electric lights limits the time of exposure, as the faintest stars do not appear when the fogging of the plates exceeds a small amount. For this reason, an exposure of three hours with the 8-inch Draper telescope fails to show faint stars any better than an exposure of one hour; and this instrument is not used, even for exposures of ten minutes, for several days each month, on account of the Moon. Several of the brighter asteroids are photographed every month as standards of magnitude in different parts of the sky.

Boyden Department.—The station at Arequipa remained under the charge of Mr. H. C. BAILEY from October 1, 1901, to March 1, 1902. It was in charge of Mr. R. H. FROST from March 1 to June 1, 1902, and since June 1, 1902, in charge of Professor BAILEY. The number of photographs taken with the 13-inch Boyden telescope is 276, making 10,630 in all. A few of these are charts of clusters, but nearly all of the remainder are photographs of the spectra of stars in which the hydrogen lines appear to be variable, and of spectroscopic binaries. Two thousand one hundred and forty plates have been taken with the Bache telescope, making 30,748 in all. Nearly all of them are charts with exposures of 10^m and 60^m. The total number of photographs taken at Arequipa during the year is 3,919. One reason for Professor BAILEY's trip to Peru was to study the variations in light of the planet *Eros.* At its next opposition, this planet is so far south that it cannot readily be observed in Europe or in the United States, and is so faint that powerful instruments will be required to observe it. The meridian photometer has accordingly been sent to Peru to determine standards for comparison, and also to continue the work undertaken here, as described above. One of the photometers used in the determination of faint stellar magnitudes by the co-operation of the Yerkes, Lick, McCormick, and Harvard Observatories, has also been sent to Peru. This photometer has been attached to the 13-inch Boyden telescope, and has already been used by Mr. BAILEY on 24 nights, from July 28 to September 30, 1902. Measurements have been made with it of *Sirona, Tercidina,* of camparison-stars for variables, and of a few variables. Attempts have been made to secure monthly observations, by ARGELANDER'S method, of 50 southern variables. This has been much interrupted by other work, but since March, 1902, it has been actively resumed.

Bruce Photographic Telescope.—During the last year, 438 plates have been taken with the Bruce photographic telescope, making 6,174 in all. Before February 1, 1902, these plates were taken by Dr. DELISLE STEWART, and since then by Mr. R. H. FROST. With this instrument, excellent chart plates can be obtained of regions 5° square, the images in the centers of the plates being almost perfectly circular even when the exposure lasts four or five hours. A large number of trails of asteroids have been photographed, several of which are probably new. One of these has a greater eccentricity than any other known asteroid, and exceeds that of some of the periodic comets. The name *Ocllo* has been given to it by the discoverer, Dr. STEWART, after the Peruvian goddess, who with her brother Manco was supposed by the Incas to have descended from the Sun. A photograph of *Eros* was obtained on July 7, 1902, nearly a month before it was observed elsewhere after its conjunction with the Sun.

Blue Hill Meteorological Observatory.—The work of the Observatory was performed, under the direction and at the expense of Mr. ROTCH, by the three assistants formerly employed. The special investigations in 1902 included determinations by day and night of the atmospheric refraction above land and water, and a few measurements of the quantity of carbon dioxide in the air and of the electrical potential of the air, by Mr. G. W. PICKARD. Commencing in December, kite-flights were made on a fixed day each month, in co-operation with simultaneous ascensions of balloons and kites in Europe. The mean altitude above the sea of the meteorograph in the ten flights at Blue Hill was 9,200 feet, which is 1,925 feet above the mean of the flights during the preceding year, and is the highest annual average yet attained. The maximum altitude of 14,060 feet exceeds by 1,510 feet the highest flight of the year before. Mr. ROTCH's project of exploring the atmosphere above the tropics and the Equator with kites flown from a steamship was approved by the International Aeronautical Congress that met at Berlin in May, and he has requested a grant from the Carnegie Institution to partially defray the cost of the expedition. The Observatory is being remodeled, and a much needed fireproof building for the library and records generously added by Mr. ROTCH, at an approximate cost of $6,000.

Library.—The library of the Observatory has been increased by 292 volumes and 973 pamphlets. The total numbers of volumes and pamphlets in the library on October 1, 1902, were 10,369 and 17,179, respectively. Special efforts are being made to render the meteorological, as well as the astronomical, collection of publications here and at Arequipa as complete as possible. Owing to the number of buildings connected with the Observatory, duplicates of important publications are in constant use. Every year the need of additional space for books is becoming more urgent.

Telegraphic Announcements.—Of the 22 messages distributed this year, 4 were received from Professor KREUTZ, Kiel, 9 from the Lick Observatory, 3 from the Yerkes Observatory, 2 from Professor BROOKS, and one each from four other sources. The distribution of the announcements by telegraph is continued to such subscribers as wish to pay for the messages.

Time Service.—On June 14, 1902, a new system of public time signals, devised by Mr. GERRISH, was put into operation. Incandescent electric lights are made to pulsate in response to the telegraphic signals of the standard clock, reproducing visually the regular standard signals which have hitherto been sent out by telegraph.

Publications.—Volumes XXXVI, part II, XXXVIII, XLI, Nos. VII, VIII, and IX, XLIII, part II, and XLVIII, No. I, have been printed and distributed. Volume XLIV, part II, Reduction of Observations made with the Meridian Photometer during the years 1892 to 1898, is in type. Fifty-five pages of volume XLVI, Observations of Southern Stars, made with the Meridian Photometer in 1899, 17 pages of volume XLVII, Observations of Photographic Variables, pages 39 to 83 of volume XLVIII, Observations of the Light Curve of *Nova Persei,* No. 2, and 14 pages of volume XLIX, Photometric Observations made with the East equatorial, are in type.

The first forty-five volumes of the Annals are therefore completed, with the exception of volumes XXXIX, XLIII, and XLIV, of which the first portions only have been distributed. The four volumes following XLV have also been begun. Four circulars have been issued during the year: 62. Spectrum of Lightning (November 16, 1901); 63. An Asteroid Orbit of Great Eccentricity (November 19, 1901); 64. Early Observations of *Algol* Stars (January 18, 1902); 65. A New *Algol* Variable (May 6, 1902).

The building containing the collection of photographs of the sky had become so crowded that no room was available for the additional photographs which are made on every clear night, and yet the value of the collection is increasing every year, and furnishes the only existing history of the stellar universe for a definite number of successive years. A friend has presented the Observatory with $20,000, making no condition except that the name of the donor should not be mentioned. A portion of this gift has enabled the Director to add to the building containing these photographs a fireproof wing of plain brick; it will provide for the growth of the collection during the next ten or fifteen years. Again, recent experiments have proved that a large reflector will show stars so faint that their study with other telescopes is impossible. We have contracted with the firm of ALVAN CLARK & SONS for a mirror two feet in diameter, to be used first on the northern and then on the southern stars, thus extending our work to vast multitudes of stars hitherto beyond our reach. The mounting will be constructed in our own workshop with a great saving of expense. It is hoped that results will be such as to influence others by the example of this gift, so that the other departments of the Observatory may be made to correspond to its great development in certain directions. The library of the Observatory, one of the most complete and valuable in the world, is in a wooden building half a century old and is liable to destruction by fire at any time.

The building containing the photographic laboratory and machine shop is also of wood and wholly inadequate for these purposes.

Another anonymous gift has been received, which is of interest as suggesting a much wider field of usefulness for the Observatory than it now occupies. This gift at present amounts to $70,000, of which $10,000 is at once available. The income may be used for any astronomical work, whether undertaken at the Harvard Observatory or elsewhere. The first appropriation was made last summer to furnish an assistant at another observatory, so that one of the largest telescopes in the world could be used during hours at which it would otherwise be idle. The Director of the Harvard Observatory is always likely to know of ways in which money could be expended to especial advantage for astronomical research. A pamphlet was published in 1886 by the undersigned, recommending the establishment of such a fund, and in 1890 Miss C. W. Bruce gave $6,000, which was expended in this way. It is believed that the results attained show how advantageously such a fund can be administered here. The usefulness of this Observatory would be greatly increased if it should become an important part of the duty of its Director to aid other observatories and astronomers, to secure observations in neglected departments of astronomy, and to enable competent observers to use the numerous large and valuable telescopes now idle. It seems as if the moral effect of thus bringing together the astronomers of the world so that they might work harmoniously on researches too large to be undertaken by any one of them, must appeal to some of the many friends and patrons that astronomy has always had. The pamphlet mentioned above contains the reasons for believing that great permanency of good management, and efficiency in the expenditure of such a fund could be attained here. At least, the present condition of the Observatory is such as to insure the immediate expenditure of several thousand dollars a year to great advantage in this way.

Edward C. Pickering, *Director.*

THE CINCINNATI OBSERVATORY.

As the staff of the observatory consists of but two,—the director and one assistant,—as considerable teaching is required, the scientific work that can be accomplished is quite limited.

Observations for the variation of latitude, undertaken in connection with the International Geodetic Association, have been prosecuted during the year 1902 as usual. For this work the zenith telescope loaned by the U. S. Coast and Geodetic Survey has been employed. This instrument is by Wanschaff, and is similar in construction to those of the four main stations, but somewhat smaller. The number of pairs of stars secured is as follows:—

January . . .	116	July.	166
February . .	86	August . . .	165
March	130	September . .	15
April	118	October . . .	155
May.	154	November . .	136
June	122	December . .	72
		Total .	1,435

The meridian-circle has been employed in the redetermination of the stars of Piazzi's catalogue north of the equator. About 3,000 observations were secured, and this scheme of work is now nearly completed.

The weather during the year has been much more unfavorable than in 1901. J. G. Porter, *Director.*

INTERNATIONAL LATITUDE STATION, UKIAH, CALIFORNIA.

The programme of the International Geodetic Association for observing variations of latitude was continued throughout 1902 without modification or interruption. The number of pairs observed in each month is given below:—

1902, January . . .	150 pairs	1902, July.	207 pairs
February . .	37	August . . .	215
March	188	September . .	180
April	167	October . . .	194
May.	173	November . .	157
June	199	December . .	155

The total number is 2,022. The conditions that prevailed in February are not likely to be repeated here soon; during this month 19.4 inches of rain fell, more than during any other month since 1877, when the meteorological records for this place were begun.

Besides these observations for latitude proper, auxiliary observations were made for determinations of the instrument's position and adjustment, of the micrometer value, of the values of the level spaces, and of the periodic errors of the micrometer-screw.

FRANK SCHLESINGER.

2 Jan., 1903.

GENERAL NOTES.

By **Frank Schlesinger.**

The Constant of Aberration and the Solar Parallax.—Recent series of observations, and the recomputation of earlier ones when the variation of latitude is taken into account, indicate that the value hitherto assigned to the constant of aberration is too small by about 0".05. It is only a few years since the heads of four national observatories and several other prominent astronomers met at Paris to recommend a series of constants for uniform use in the ephemerides. The value of the aberration there adopted was 20".47, replacing **Struve's** classic value of 20".445; but now it seems nearly certain that the true value is above 20".50, and probably 20".52 would be the nearest estimate which our present knowledge permits us to make.*

So far as the requirements of the ephemerides are concerned, this modification of the value of the aberration would not be of great consequence; at most it corresponds to a change of a few hundredths of a second of arc in the "reduction to apparent place" of the stars. But when we consider the aberration in connection with the solar parallax, for example, a change of 0".05 is a most important one. These two quantities (usually denoted by k and π respectively) are related to V, the velocity of light *in vacuo*, by the simple equation,

$$k \times \pi \times V = \text{a constant}$$

This constant is known with great precision, its probable error not exceeding one part in twenty thousand. The velocity of light is also known quite accurately,—compared with our knowledge of k and of π,—its probable error not being greater than one part in two thousand. If we replace the constant and V in the above equation by their standard values, we get a relation between k and π. The table below shows what values of the solar parallax would follow from various values of the aberration when we use this relation:—

20".445 (**Struve's** value)	8".813
20 .47 (Paris Conference)	8 .802
20 .52	8 .781

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* In *Astronomical Journal* No. 529, which has come to hand since this note was written, Dr. **Chandler** expresses the conviction that the "real value of this much disputed constant is likely to be found near or slightly above 20".52."

Thus we see that the new value of the aberration implies a solar parallax about 0″.02 smaller than the usually accepted value of 8″.80. The latter is the result of so much labor and ingenuity that we should hardly expect it to be in error by so much, and it is therefore difficult to reconcile the results of observations on these two constants. Perhaps the completion of the *Eros* work and the more accurate knowledge of latitude variations that is now being accumulated may cause this difficulty to disappear.

In this connection there is another consideration which should be mentioned, though it is rather of philosophical than of practical interest. The equation which we have used to connect the aberration with the solar parallax and the velocity of light has never been rigorously demonstrated. It is equivalent to the explanation advanced by BRADLEY when he discovered the aberration nearly two centuries ago (1729). Now, in BRADLEY's time the corpuscular theory of light, resting on the great authority of NEWTON, was universally accepted: and if this theory were the true one, BRADLEY's explanation, and therefore our equation, would be rigorously demonstrated. We know now that light is a series of undulations in the ether, and that BRADLEY's explanation is no longer satisfactory. The difficulty arises from the unknown effect of the relative motion of Earth and ether. The reader is referred to the article on "Ether" by J. CLERK MAXWELL in the *Encyclopædia Britannica* (Ninth Edition, Vol. VIII, pp. 503 et seq.), and to Mr. SEABROKE's presidential address, printed in the Journal of the British Astronomical Association (Vol. XII, No. 1). This problem demands the use of the most refined mathematical analysis. It has been attacked by some strong men, but a complete solution is still wanting, and some unpalatable assumptions have been made with regard to the nature of the ether. While we need hardly fear a modification of our equation to a degree which present methods of observation could appreciate, it would certainly be a great satisfaction to know just how close an approximation it is and to have a complete theory of aberration.

The Difficulty of Determining the Constant of Aberration.—The two constants that we have been discussing happen to be among the most difficult to determine among all those with which astronomy has to do. That this is true of the solar parallax is well known and understood, but the difficulty of determining the constant of aberration seems not to be so generally recognized. In considering the accuracy attainable for various astronomical phenomena, an obvious distinction presents itself between such as are *accumulative* in their character and those that are *periodic* or *stationary*. The former have a faculty of taking care of themselves, so to speak, with the lapse of time. For example, we can determine the annual precession of the equinoxes with any required degree of accuracy from two series of observations of the Sun and the stars, no matter how rough these may be, providing only that the interval of time between the two series be great enough. From a comparison of the observations of HIPPARCHUS and of TYCHO BRAHE we can get the annual precession with greater accuracy than attaches at present to many of the constants of astronomy. In this class with precession belong the proper motions of the stars, the rotation periods of the Sun and the planets, the periods of revolution (and therefore the relative distances) of planets around the Sun and of satellites around planets, the periods of variable and binary stars, and indeed all the periods in astronomy.

The other class of phenomena, those which receive no such powerful aid from time, are not susceptible of so great accuracy. These must depend upon the mere accumulation of observations or upon improvements in instruments and methods. The number of astronomical phenomena here included is practically without limit, but among them we may distinguish as especially difficult of determination those that have an annual period; the absolute parallax of a fixed star and the aberration are examples. Either of these depends essentially upon the accurate observation of the place of a star at two opposite seasons of the year. Now, it would be desirable that these observations should be made under nearly uniform conditions, but it is easy to see that changes of season make this impossible. Let us suppose, for example, that the apparent place of the star varies slightly with temperature; then our summer results will differ systematically from those of the winter, and error will creep into our determination of parallax or aberration. It is true that the effects of temperature are understood and may be approximately allowed for, but there are other effects that come with the changes of season which have not been reduced to law, or, worst of all, whose very existence is not suspected. No better example in this connection could be cited than Airy's experience with the *reflex zenith-tube* at Greenwich. A long and careful series of observations upon a certain star with this instrument yielded a value for the aberration which is certainly too small by nearly 0".2. It was not until long after the instrument had been all but abandoned that the mystery was explained away by Chandler; the latitude variation (a phenomenon unsuspected by Airy or any of his contemporaries) has, among others, an annual term. These others are eliminated, so far as the aberration is concerned, in a series of observations extending over many years. But as the annual term did not vary to any great extent in this period, its effects were practically repeated from year to year, and were closely interwoven with those of the aberration itself, the periods of the two being identical. The annual term in the latitude variations certainly has its cause in the changes of season, and we may be sure that similar effects, though perhaps none so great, lie hidden in observations of our day and of the past, to be unearthed by astronomers of the future.

Comet Notes.—Four comets were discovered in 1902—

a by Brooks,	Geneva, N. Y.,	on	April 14.
b by Perrine,	Lick Observatory,	on	August 31.
c by Grigg,	New Zealand,	on	July 23.
d by Giacobini,	Nice,	on	December 2

Comet *b* (Perrine) was for several weeks an easy naked-eye object, having attained at one time the brightness of a fourth-magnitude star. This comet is also interesting on account of its close approach to *Mercury* on November 30th, which may lead to a valuable determination of the planet's mass from its effect upon the comet's orbit. Luckily this comet has a well-defined nucleus, so that accurate measures of its position are possible.

Comet *c*, not an excessively faint object and well located for observations in both hemispheres, was nevertheless seen only by its discoverer, Mr. John Grigg, of Thames, New

Zealand. Mr. GRIGG lacked the means for any but very rough measurements of the comet's position; so that the seemingly impossible thing has happened, in this day of many telescopes and of telegraph and cable, that we know practically nothing of the orbit of a comet which would probably have been visible for several weeks in telescopes of moderate size. No doubt it happens quite often that a comet visits the solar system without being detected at all; but if once seen, usually only a few hours elapse until a score of telescopes have been pointed to it, at observatories scattered around the Earth.

Nevertheless, comets are certainly accorded a better welcome now than two or three generations ago. Perhaps it would not be citing too extreme a case to mention Comet 1827 I as an example of how comets were observed at that day. The definitive orbit of this comet has been published in *Astronomische Nachrichten,* No. 3830, by Doctor STRÖMGREN. The comet was discovered by PONS, of Florence, on December 26, 1826, and observations were made of it there on December 27th, 28th, 30th, and 31st, but on no other dates. Evidently the news of the discovery did not get abroad until the middle of January, for the next observation was made on January 17th, by HARDING, at Göttingen; eight other observations were secured at Bremen and Kremsmünster by January 26th, the last date on which the comet was seen. But the inadequacy of the data for computing an orbit does not appear until the character of the observations is examined. The Florence observations seem to be inferior to what one might make with the naked eye upon a sufficiently bright comet; the residuals obtained by comparison with a preliminary orbit average over ten minutes of arc, even after rejecting one observation whose residual is 46′. The single Göttingen place is hardly better, the residual in R. A. being 5′.8, and in declination 3′.6. The four Kremsmünster observations in their original form were very wild, but they were much improved by Dr. STRÖMGREN'S new reduction of them. The four observations at Bremen were made by OLBERS, and are, of course, good for that day, but unfortunately they embrace a period of only four days. Thus the orbit of this comet rests on the eight observations made at Bremen and Kremsmünster, and these were all made between January 18th and January 26th.

Nova Persei.—The great usefulness of the Harvard photographs has again been shown by an important discovery with regard to the early history of *Nova Persei.* Father ZWACK, of the Georgetown College Observatory, some time ago called Professor PICKERING's attention to a faint star on one of the early Harvard plates, at or very near the position now occupied by *Nova Persei.* Careful measurements show that the two objects are in all probability identical, and furthermore it appears that the faint star was a variable, with a range of about one magnitude and a maximum brightness of the thirteenth magnitude. One other *Nova,* that of 1866 in *Corona Borealis,* is known to have existed before its outburst, having been recorded in the Bonn *Durchmusterung.*

This discovery with regard to *Nova Persei* tends still further to do away with the distinction between variable and temporary stars. Indeed, if it should be found that *Nova Persei* will again become variable there is little distinction, except in degree, between its fluctuations and those of *Mira Ceti,* for example.

It was stated in General Notes, No. 86 of these *Publications,* that *Eros* is the only exception to the rule that minor planets should have feminine names. Professor TURNER points out in *Observatory* that another exception is presented by planet (342), which is named *Endymion.*

Laws Observatory, of Missouri University, has adopted the method of publication by Bulletins, and No. 1 has been distributed. This is entitled "Observations and Elements of Comet *b* 1902 (PERRINE)," by Professor F. H. SEARES. The observations are 30 in number, and extend from September 4 to October 28, 1902. Upon these is based a computation of the orbit of the comet by an adaptation of LEUSCHNER's recent method.

Herschel's Nebulous Regions.—The elder HERSCHEL noted during his sweeps 52 regions "affected with nebulosity," and published in the *Philosophical Transactions* brief descriptions of them, with their approximate positions and dimensions. Doctor ISAAC ROBERTS has recently photographed all these regions with a 20-inch reflector and exposures of 90 minutes each. These should show, according to the estimate of Dr. ROBERTS, stars as faint as the sixteenth or seventeenth magnitude, but the result is reached that the nebulosity of only four of the regions is confirmed. This result is all the more surprising becausing HERSCHEL'S notes do not indicate that these four regions are more affected than some of the others. As it is hard to understand how HERSCHEL could be so greatly mistaken, and still more difficult to see how these photographs can be in error, a repetition elsewhere of Dr. ROBERTS'S survey would be most valuable.

Jan. 15, 1903.

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD IN THE ROOMS OF THE SOCIETY, JANUARY 31, 1903, AT 7:30 P.M.

President PERRINE presided. A quorum was present. The minutes of the last meeting were approved.

The following new members were duly elected:—

LIST OF MEMBERS ELECTED JANUARY 31, 1903.

Mr. WM. GRANT . . . . 104 Sutter Street, S. F., Cal.
LIBRARY OF THE UNIVERSITY OF SOFIA . . . . Sofia, Bulgaria, Europe.
Mr JOHN L. MCNAB . . . . Ukiah, Cal.

A committee to nominate a list of eleven Directors and Committee on Publication, to be voted for at the annual meeting, to be held on March 28th, was appointed as follows: Messrs. WM. H. LOWDEN (Chairman), JOS D. GRANT, GEO. C. EDWARDS, CHAS. NELSON, J. O'B. GUNN.

A committee to audit the accounts of the Treasurer, and to report at the annual meeting in March, was appointed as follows: Messrs. CHAS S. CUSHING (Chairman), JOS. A. DONOHOE, L. H. PIERSON.

The following resolution was unanimously adopted:—

Resolved, That Mr. WM. M. PIERSON, on account of the exceptional aid, both professional and financial, which he has rendered this Society, is entitled to the gratitude of all its members and is deserving of such marks of esteem as this Board has the power to grant; and it is therefore further

Resolved, That Mr. PIERSON be, and he hereby is, elected a Life Member of this Society.

It was upon motion

Resolved, That the Reports of the U. S. Commissioner of Education contained in the Library be presented by this Society to the Library of the University of California.

AMENDMENT TO THE BY-LAWS.

The following amendment to the By-Laws was duly adopted by the consenting votes of nine Directors, namely, Messrs C. D. PERRINE, A. O. LEUSCHNER, S. D. TOWNLEY, WM. M. PIERSON, CHAS. S. CUSHING, E. J. MOLERA, A. H. BABCOCK, F. R. ZIEL, Miss R. O'HALLORAN:—

ARTICLE VIII.

Each active member shall pay, as annual dues, the sum of five dollars, due on the first day of January of each year, in advance. When a new member is elected during the first quarter of any year, he shall pay full dues for such year; when elected during the second quarter, he shall pay three fourths only of such dues; when elected during the third quarter, he shall pay one half only of such dues; when elected during the last quarter, he shall pay one fourth only of such dues; provided, however, that one half only of the dues in this article provided for shall be collected from any member who is actually enrolled as a student at a university, seminary, high school, or other similar institution of learning, during such time as he is so enrolled. No one shall be deemed an active member, or receive a diploma, until he has signed the register of members, or accepted his election to membership in writing, and paid his dues for the current year. Any member may be released from annual dues by the payment of fifty dollars at one time, and placed on the roll of life members by the vote of the Board of Directors. Any failure on the part of a member to pay his dues within six months after the time the same shall have become payable, may, at the discretion of the Board of Directors, be considered equivalent to a resignation.

Adjourned.

MINUTES OF THE MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD IN THE LECTURE HALL OF THE CALIFORNIA ACADEMY OF SCIENCES, JANUARY 31, 1903, AT 8 P.M.

President PERRINE presided. The minutes of the last meeting were approved.

The following papers were presented:—

The Total Light of the Stars, by Dr. S. D. TOWNLEY.
Planetary Phenomena for March aud April, 1903, by Prof. M. McNEILL.

The Secretary read the names of new members elected.

Mr. BURCKHALTER, in behalf of the Comet Medal Committee, presented the Donohoe Comet-Medal to Prof. PERRINE for his discovery of Comet *b* 1902.

The President then introduced the lecturer of the evening Dr. S. D. TOWNLEY, who gave an account of his recent investigations in reference to the total light of the stars. An abstract of his paper is contained in this number of the *Publications*.

The meeting then adjourned.

OFFICERS OF THE SOCIETY.

Mr. C. D. PERRINE	*President*
Mr. S. D. TOWNLEY	*First Vice-President*
Miss R. O'HALLORAN	*Second Vice-President*
Mr. CHAS. S. CUSHING	*Third Vice-President*
Mr. R. G. AITKEN Mr. F. R. ZIEL	*Secretaries*
Mr. F. R. ZIEL	*Treasurer*

Board of Directors—Messrs. AITKEN, BABCOCK, CAMPBELL, CUSHING, LEUSCHNER, MOLERA, Miss O'HALLORAN, Messrs. PERRINE, PIERSON, TOWNLEY, ZIEL.

Finance Committee—Messrs. PIERSON, CUSHING, BABCOCK.

Committee on Publication—Messrs. AITKEN, GALLOWAY, SCHLESINGER.

Library Committee—Mr. TOWNLEY, Miss O'HALLORAN, Mr. BRASCH.

Committee on the Comet-Medal—Messrs. CAMPBELL (*ex-officio*), PIERSON, BURCKHALTER.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. RUTHVEN W. PIKE.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. FELIPE VALLE.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.
(February, April, June, August, October, December.)

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ADDRESS OF THE RETIRING PRESIDENT OF THE SOCIETY READ AT THE FIFTEENTH ANNUAL MEETING, MARCH 28, 1903.

By C. D. Perrine.

It has been the custom for the retiring Presidents to address the Society on the occasions of its annual meetings. The award of the Bruce Gold Medal since its foundation, and an account of the work of the recipient has occupied, naturally, the chief place in these annual addresses. As no award of the medal has been made this year, I shall take the opportunity to review the progress of the Society in certain directions, with a view to pointing out some of its most useful fields and urgent needs.

The formation of the Society was almost spontaneous, and the direct result of the solar eclipse of New Year's day, 1889, when so many of the amateur photographers visited the region of totality in northern California. At the time of its organization, the Astronomical Society of the Pacific was the only active astronomical association in the United States, amateur or professional.

One of the first acts of the Society was to commence a series of *Publications* to contain popular accounts of current astronomical work and observations made by its members. As there were at this time but two journals in America devoted entirely to astronomical science, there was also a wide and useful field for the Society's publications in printing original investigations. This field was at once occupied as fully as the conditions would permit. Although the Society was organized almost wholly of persons interested in astronomy as a pastime only, it now numbers many prominent scientists among its members, and there has been much substantial scientific work in its proceedings from the first. The result has been that its publications have taken and fill an honorable place with the scientific institutions and individuals of the world, as well as maintaining the original aim of the Society, to diffuse current astronomical information in a form to be understood by the non-professional.

Early in the history of the Society, substantial foundations began to come to it from its wealthy members. The first of these was the Comet-Medal established by JOSEPH A. DONOHOE. A number of medals and prizes for the discovery of comets had been awarded during the previous half-century. These were given principally by European rulers and one or two scientific societies, and were awarded in specific cases. There was no permanent foundation for any of them, and all have been discontinued. Mr. DONOHOE'S gift was sufficient to maintain a medal in perpetuity. This medal is intended solely as a recognition of the discovery of an unexpected comet, and in no way as a reward.

The Donohoe Comet-Medal foundation was soon followed by the gift of a fund by ALEXANDER MONTGOMERY for the purchase of the nucleus of an astronomical library and for its maintenance. With this beginning the library has grown rapidly, principally through accessions by gift from observatories and scientific societies, until it now numbers over twelve hundred bound volumes and a large number of pamphlets. One of the very useful fields for the Society is to own a complete astronomical library, and to have it available for reference purposes.

In 1897 Miss CATHERINE WOLFE BRUCE, who has done so much for astronomical science on both sides of the Atlantic, gave the Society a sum of money sufficient to maintain a gold medal, to be awarded to those astronomers who have done most to advance the science. The Bruce Gold Medal, like the Donohoe Comet-Medal, is international in character.

In 1892 it was decided to place the fees of the life members in a separate fund, so long as the member lived. At his death the fee was to be used for the general expenses of the Society. Previous to this time all such fees had been put into the General Fund. After 1892, however, all the fees received from life members were placed in the Life Membership Fund, and any surplus general funds at the end of the year were also transferred toward the representation of the full number of life members, until at present this fund contains $1,700. As there are seventy life members, the present balance is only about half as large as it should be. This fund is intended as a guarantee to the members who have paid their dues long in advance.

The Society has suffered the loss by death, during the past year, of several of its members. Two of them bequeathed substantial sums of money to the Society: Mr. MORRIS REIMAN, of Chicago, left the sum of $500, and Mr. JOHN DOLBEER, of San Francisco, the sum of $5,000. I believe that no conditions have been attached to either of these gifts. They can, therefore, be used in the way most beneficial to the Society. It is not too much to say that such bequests are of the highest possible value. They are extremely adaptable and thus available for a great variety of purposes.

Such bequests should be made of perpetual use, by treating them as endowments or expending them for some concrete purpose. In the present state of our Society, with so many funds already established for specific purposes, and the need for a larger yearly income, there can be no doubt as to the disposition that should be made of them. They should be invested in good interest-bearing securities and the incomes only used. Each fund should be kept entirely distinct, and should, of course, bear the name of the donor. The incomes should be expended, as far as possible, for some particular purpose, so that proper recognition may always be accorded and the usefulness of such gifts traced.

The income of the Reiman Fund may very properly accumulate for several years until there is sufficient to furnish a high-class illustration for one of the *Publications*. Such illustrations are badly needed.

The greater income from the Dolbeer Fund will fill a larger field. The most pressing need now is towards an enlargement of our *Publications* and a greater number of illustrations for them of the highest excellence. No better immediate use can be found for the income from this fund than to supply some of these urgent needs of the *Publications*. If these wants are supplied later through other channels,—and it is hoped that they will be,—the income of the Dolbeer fund would be relieved and could be applied to other purposes. I may mention some ways in which such incomes could be most usefully expended.

Our knowledge of comets, particularly of their origin and family history, is to be increased principally through observations of those which are permanent members of the solar system. Many periodic comets have been discovered, but a large proportion of them have been missed at subsequent returns to perihelion and entirely lost. The searching for these bodies at their predicted returns is usually done at some of the large observatories having powerful telescopes, and, recognizing the importance of the work, it is conscientiously prosecuted. In many cases where the return of such a comet has been missed it is undoubtedly because the comet has become too faint to be seen even with powerful telescopes. But it is probable that some comets, at least, have been missed because unknown disturbances in their orbits have occurred, which caused them to be so far from their predicted places as to be beyond the region searched. The field of a large telescope is so limited that it is only possible to sweep over a comparatively small area of sky in the time usually available for such searches. When near perihelion and at their greatest brightness, these comets are frequently on the opposite side of the Sun from the Earth, and so nearly in the same line, that only a short time is available after sunset or before sunrise for the search. It is therefore desirable for as many observers as possible to take part in the searches. Encouragement is needed to induce those not now engaged in such work to take it up. The best form for such encouragement would be money prizes for the re-discovery of such periodic comets as have been observed at only one apparition, or those which are of special importance and are likely to pass unobserved. The amount of the prize could be varied according to the importance of the discovery.

Another field which requires exploiting is that of simplifying the numerical operations in astronomical computations and adapting mechanism to the solution of problems which must be repeated many times. The growth of astronomical work has been so rapid that there is now in all observatories and computing bureaus a great amount of routine calculation.

Calculating-machines have been invented to perform the simple arithmetical operations and have proven most valuable. We need, however, to go a step farther and put some steel brains into them, so that they will perform all the operations in a given problem, *e. g.* the computation of ephemerides, reductions of star-places, etc. Many of these special problems can be solved by machinery, and the time has come to encourage its invention. This can best be done by offering substantial prizes for machines which will satisfactorily do specific pieces of work.

It is one of the functions of a scientific society to assist investigators and inventors in the solution of special problems. Instances of members of this Society supplying such aid are not wanting. I need only mention such names as MILLS, CROCKER, HEARST, BRUCE, DOLBEER, and PIERSON to recall some of them.

The wide field that is open to our publications has already been spoken of. This field is only partially occupied at present, owing to a lack of funds. The income from the members, after meeting the general expenses of the Society, is only sufficient to maintain the publications in their present quantity. A Publication Fund of $25,000 is badly needed to permit of the necessary expansion and improvement. The income from such a fund, together with the amount which would be available from the General Fund, would meet this demand.

Another of the ways in which the Society can be very useful is in creating and maintaining an interest in actual observation of the heavens. In San Francisco there are many people who are already interested in astronomy and many more who would become interested and find pleasure and instruction in looking at the wealth of objects which are to be seen with a telescope of some power. The matter of an observatory for the Society was broached a number of years ago and a site in Golden Gate Park secured. I take this occasion to again call attention to the desirability of such an establishment. An equatorial telescope of ten or twelve inches aperture, with the necessary accessories and a suitable dome and observatory building, would cost about $10,000.

I have spoken freely of some of the more important ways in which the Society can be aided financially, in the hope that some of our members, knowing of them, may be able to assist in supplying them.

The broadening influence of science, and particularly astronomy, cannot be overestimated. As the public school has become the birthright of every American boy and girl, so will a knowledge of science be looked upon in future years as a necessary part of their course of study and one of the most potent of civilizing forces.

Perhaps the most important of the fields open to our Society is that of diffusing a more general knowledge of astronomical science.

A suggestion has been made by one of our members which, if it can be carried out, would be most fitting and in many ways a benefit to the Society. It is that the Society become one of the affiliated institutions of the State University. It seems eminently proper that scientific societies should cluster around a great University.

It has been found that more or less confusion in regard to finances arose from the non-coincidence of our fiscal year with the calendar year. To obviate this difficulty two financial reports are rendered at this meeting, one covering the period from April 1, to December 31, 1902; the other from January 1, to March 31, 1903.

It seems to me that we should avoid, if possible, paying a deficit out of the income from the following year (which has its own proper demand). Accumulated deficiencies, which are possible in this way, will cause a stagnation and endanger the usefulness of the Society.

Article IX of the By-Laws has been amended so that the meetings of the Society are made more uniform and convenient.

To encourage students in universities and high schools to become members of the Society, special provisions have been made whereby their fees are reduced during such time as they are actually enrolled as students. It is hoped in this way to give many an opportunity of enjoying membership who otherwise would be debarred for several years.

It is highly desirable, as soon as arrangements can be made to do so, that the rooms and library of the Society be kept open during the greater part of each week-day. The library should be much more accessible than it now is.

At present there are but three meetings of the Society in San Francisco. These are public meetings. A system of informal meetings for reading and discussion, if inaugurated by the members residing in and about San Francisco, would be found very helpful. Such meetings could be held monthly, or weekly if desirable.

In conclusion, I wish to thank the officers and members of the Society for their cordial help and co-operation during the past year. Without such assistance my duties would have been much less easy.

MT. HAMILTON, CAL., March 16, 1903.

PARALLAX OF THE BINARY SYSTEM *DELTA EQUULEI.*[*]

BY W. J. HUSSEY.

The object of this communication is to present a value of the parallax to δ *Equulei* obtained by using as data the elements of the orbit derived from micrometrical measures and the relative velocity of the components in the line of sight furnished by spectroscopic observations. While the result given is merely provisional, one to be improved when better elements of the orbit are available, as they no doubt will be after two or three years more, yet it is thought that it has already a measure of certainty which places it in the list with the more accurately determined stellar parallaxes. Moreover, the manner of its derivation differs from previous determinations. The use of comparison-stars and the uncertainties of their assumed distances are eliminated. In theory the method leads to an absolute value of the parallax, and not to a relative one, as is necessarily the case when comparison-stars are employed.

The mathematical relations connecting the elements of the orbit of a binary, the relative velocity of its components in the line of sight, and the parallax of the system, have long been known. Applications have hitherto been wanting for the reason that no double stars had been found which furnished all the data needed. δ *Equulei* has proven an exception. The elements of its orbit are approximately known, and in 1901, at the time of the last periastron passage, the relative velocity of the components in the line of sight was so great that the spectra of the two stars were displaced to a measureable extent.

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[*] *Bulletin* of the Lick Observatory, No. 32.

In the *Monthly Notices* of the Royal Astronomical Society for March, 1890, Professor ARTHUR A. RAMBAUT has given the following simple formula for computing the parallax of a binary from the data here considered:—

$$\pi = \frac{l\, a^2 \sqrt{1 - e^2}\, \sin\,(\phi - \lambda)\, \sin\, i}{V\, P\, r \sqrt{1 - e^2 \cos^2 \phi}}.$$

In this equation P denotes the periodic time, a the mean distance, e the eccentricity, i the inclination, r the radius vector, λ the angle between the line of nodes and the major axis of the true ellipse, ϕ the angle between the tangent to the orbit and the major axis, V the relative velocity of the components in the line of sight as furnished by the spectroscopic observations, l the velocity of the Earth in its orbit, and π the parallax of the system.

The elements of the orbit of δ *Equulei* are still imperfectly known. A nearly continuous record of the motion of the companion during the next three years is necessary to remove effectively the uncertainties which still exist in their values. Eight times since the discovery of this binary the companion has passed over the arc which it will describe during the next three years, and numerous observations relate to this portion of the orbit. But the measures are more or less discordant, and on this account additional ones are required to fix with certainty the direction and magnitude of the greatest apparent distance. When these measures are obtained and the elements of the orbit revised we shall have the data which will give an accurate value of the parallax of the system. A consideration of the material at present available appears to show that the changes which will probably take place in the elements due to the revision of the orbit will not greatly alter the value of the parallax which may now be derived, and it is on this account that a provisional value is here presented.

During the past three years this binary has been followed closely at the Lick Observatory, and much has been done to advance our knowledge of its orbit. It has been shown that the periodic time is about 5.7 years; that the last epoch of periastron passage was about 1901.5; that the apparent distance at periastron is about 0".15; that the inclination is greater than given by the elements which I printed in the *Publications* of the Astronomical Society of the Pacific for December, 1900, and afterwards in Volume V of the *Publications* of the Lick Observatory, being perhaps as much as 82° or 83°; and that the mean distance is probably a little larger than given by those elements. Further, it is known that the line of nodes and the projection of the major axis of the orbit are nearly coincident.

If we retain the line of nodes and the angle between the line of nodes and the major axis of the true ellipse as given by my published elements, and put the mean distance equal to 0″.28 and the eccentricity equal to 0.46, we get 0″.151 and 0″.409 as the periastron and apastron distances.

The relative velocity of the components in the line of sight at the epoch of periastron passage, as determined by the observers using the Mills spectrograph, was about 20.5 miles per second. At the same time the Earth's orbital velocity was about 18.2 miles per second. At periastron ϕ becomes 90° or 270°, and with $\lambda = 179°$, we have $\phi - \lambda = 91°$. Substituting these values in Professor RAMBAUT'S formula we get

$$\pi = 0''.071.$$

It is evidently impossible to give the probable error of this result. Some of the quantities upon which it depends are much better determined than others. It happens that those which appear to be the most uncertain may vary considerably without greatly affecting the resulting value of the parallax. For example, considerable variations may take place in the values of i and λ without greatly changing the values of sin i and sin $(\phi - \lambda)$ which appear in the formula. Of the other quantities those which appear the least certain are the mean distance and the eccentricity. From a consideration of all the past measures it appears highly improbable that the apastron distance can be as much as 0″.05 greater or less than the value used above. If we vary the apastron distance and eccentricity together, so as to keep the already well-determined periastron distance constant, and further retain the other elements of the computation as used above, we shall find that the apastron distance and parallax increase together, but the former at about four times the rate of the latter. From this consideration it appears improbable that the parallax will be altered so much as 0″.012, owing to changes which take place in the values of *a* and *e* due to the revision of the elements of the orbit.

The mass of the system corresponding to the parallax given above, and the mean distance and periodic time used in its derivation, is 1.89, the mass of the Sun being taken as unity. The components of this pair are slightly unequal in brightness, and perhaps also in mass. One may be as massive as the Sun, but it can not much exceed it.

The mean distance at which these stars perform their revolutions is about four times that of the Earth from the Sun. But owing to the eccentricity of the orbit the range in distance is enormous. At periastron the stars are separated by a space only a little greater than two astronomical units, while at apastron it is five of these units.

It would form an interesting analytical problem to investigate the effect of tidal action upon the relative orbit in this system. The data are pretty well ascertained. Broadly speaking, the stars have spectra of the solar type, and being comparable with the Sun in mass, it would seem not unreasonable to assume that their densities are approximately the same as that of the Sun.

February 23, 1903.

ASTRONOMICAL OBSERVATIONS IN 1902.

MADE BY TORVALD KÖHL, AT ODDER, DENMARK.

VARIABLE STARS.

Z Cygni.[*]

Jan. 1: Z invisible.
5: id.
11: id.
13: faint < e.
16: id.
June 1: = b.
28: $\left\{\begin{array}{l} < \text{c.} \\ > \text{d.} \end{array}\right.$
Sept. 7: invisible.
29: faint < e.
Oct. 8: id.

Oct. 12: id.
21: id.
25: id.
28: id.
Nov. 2: id.
20: id.
21: id.
30: = d.
Dec. 17: $\left\{\begin{array}{l} > \text{b.} \\ < \text{a.} \end{array}\right.$
20: id.

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[*] *Vide* the sketch in the *Publications* A. S. P., No. 48, page 69.

S Ursæ majoris.[*]

Jan. 1: S one step > d.
5: = d.
7: id.
11: id.
13: id.
16: id.
21: id.
30: one step < e.
Feb. 3: two steps < e.
8: id.
15: three steps < e.
22: $\left\{\begin{array}{l} < \text{e.} \\ > \text{f.} \end{array}\right.$
Mar. 3: = f.
7: id.
10: $\left\{\begin{array}{l} < \text{f.} \\ > \text{g.} \end{array}\right.$
12: one step > g.
22: = g.
24: id.
28: < g.
Apr. 5: id.
6: id.
9: id.
14: id.
June 1: $\left\{\begin{array}{l} < \text{e} \\ > \text{f} \end{array}\right\}$ nearest e.
28: = d.
Aug. 9: $\left\{\begin{array}{l} < \text{c} \\ > \text{d} \end{array}\right\}$ the middle.
11: two steps > d.
26: id.
Aug. 28: three steps > d.
Sept. 1: one step > d.
5: = d.
6: id.
7: id.
13: $\left\{\begin{array}{l} > \text{e.} \\ < \text{d.} \end{array}\right.$
17: = e.
18: id.
21: two steps < e.
22: id.
27: $\left\{\begin{array}{l} < \text{e} \\ > \text{f} \end{array}\right\}$ the middle.
29: nearest f.
Oct. 3: one step > f.
8: = f.
12: id.
21: id.
25: id.
28: id.
Nov. 2: < g.
17: invisible.
18: seen < g, air very clear.
19: id.
20: invisible.
21: 11th mag.
30: utmost faint.
Dec. 17: id.
20: > g.
21: id.

T Ursæ majoris.[†]

Jan. 1 / Mar. 3 $\Big\}$ *T* invisible.
Mar. 7: = g.
10: id.
12: = f.
22: = e.
24: $\left\{\begin{array}{l} > \text{e.} \\ < \text{d.} \end{array}\right.$
28: = d.
Apr. 5: = b.
6: id.
Apr. 9: id.
14: one step < a.
22: = a.
26: $\left\{\begin{array}{l} > \text{a.} \\ = \text{b in the sketch of } S \text{ } Ursæ. \end{array}\right.$
June 1: five steps > a.
28: $\left\{\begin{array}{l} < \text{b.} \\ > \text{c.} \end{array}\right.$
Aug. 11 / Oct. 28 $\Big\}$ invisible.

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[*] *Vide* the sketch in the *Publications* A. S. P., No. 73, page 56.

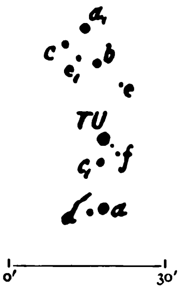
[†] *Vide* the sketch in the *Publications* A. S. P., No. 22, page 63.

Nov. 2: faint, < g.
17: one step < g.
18: id.
19: id.
20: id.
21: id.
29: = f.
Nov. 30: id.
Dec. 11: = d.
17: = b.
20: > b.
< a.
21: = a.

*W Pegasi.**

Jan. 5: W < h.
11: very faint.
13: a little increased, yet < g.
27: id.
30: almost = g.
Aug. 28: = h.
Sept. 1: id.
7: id.
Sept. 14: Almost invisible.
21: id.
27: id.
Oct. 3: id.
28: < h.
Nov. 18: id.
21: id.
30: id.
Dec. 20: id.

TU Cygni.



Jan. 1: T U < f (= 10^m).
11: id.
16: id.
June 1: = f.
Sept. 7: = c.
14: one step < b.
16: id.
17: id.
Sept. 18: = b.
21: one step > b.
22: id.
24: id.
Sept. 27: > b.
< a.
29: id.
Oct. 3: = a.
8: < a.
> b.
12: id.
21: = a.
25: id.
28: < a.
Nov. 2: id.
21: < b.
> c.
30: = c.
Dec. 17: = f.
20: < f.

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* *Vide* the sketch in the *Publications* A. S. P., No. 60, page 23. (*h* is the little star in the line between *a*₁ and *e*.)

Nova Persei.

	h.	m.		h.	m.
Jan. 1	6½ P. M.	7.2	Apr. 26	9	8.4
5	6	7.5	Aug. 11	12	9.0
6	6	7.4	26	9	9.0
7	8	7.4	28	9	9.0
11	6	7.4	Sept. 1	9	9.1
12	10½	7.4	5	9	9.1
13	8½	7.4	7	11½	9.1
14	7	7.4	13	8	9.1
16	6	7.6	14	9	9.2
21	6	7.6	16	9	9.1
27	9	8.0	17	8	9.1
30	8	7.7	18	8	9.2
31	8	8.1	19	8	9.2
Feb. 8	10	7.6	22	9	9.2
10	9½	7.6	24	8	9.1
15	7½	7.8	27	7½	9.2
22	8½	7.9	29	9½	9.2
Mar. 7	9	7.9–8.0	Oct. 3	8	9.2
8	8	8.0	12	8½	9.2
10	8	8.0	21	8	9.2
10	10	8.0	25	7	9.2
11	8½	8.2	28	8	9.2
12	8	8.2	Nov. 2	9	9.2
22	8	8.0	17	6½	9.2
24	8	8.0	18	6	9.2
27	8	8.0	21	6	9.2
28	9½	8.0	29	7½	9.2
Apr. 5	8½	8.4	30	5½	9.2
6	8½	8.0	Dec. 11	5½	9.0
9	8½	8.2	17	6½	9.3
14	9	8.1	20	5½	9.2
22	10	8.2	21	6	9.2

The Star BD 20° 1083.

This star has shown remarkable variations in the year 1902. For the comparisons I have used the following stars: *A, B,* and *b,* the variable being named *a.* The BD magnitudes are added here, but it may be noted that I always see A > B.

A = BD 20° 1095, 7.4^{m}
B = BD 20° 1093, 7.3
a = BD 20° 1083, 7.7
b = BD 20° 1073, 8.2

NOTE.—In Georgetown College's Chart II I have found among other discrepancies, No. 17 decidedly *less* than No. 20. The chart has No. 17 = 8.8 mag.; No. 20 = 8.9 mag.

When the ocular-tube is screwed out until the stars appear as pale disks, it is least difficult to state the variation.

Jan. 11: a one step > b.
30: distinctly > b.
Mar. 7: particularly bright, > b.
8: = A.
10: id.
11: id.
24: id.
27: id.
28: id.

Apr. 5: = B.
6: = A.
9: = B.
14: id.
26: id.
Oct. 25: < b.
Nov. 20: = b.
Dec. 11: > b.
17: < b.
20: id.

Occasionally I also looked out for other variables. *S Vulpeculæ* and *S Draconis* do not seem to have changed their light.

Eclipse of the Moon.

On April 22d, at sunset, according to calculation, the eclipsed Moon should have been observable at the eastern horizon, but on account of mist the red Moon was not seen until it had ascended to an altitude of 5 degrees. The shadow was touching:—

Tycho (west) at	8^{h}	57^{m} P. M.
Copernicus (east) at	8	59.5
(west) at	9	1
Plato (east) at	9	9
(west) at	9	10.5
Posidonius (west) at	9	28
Mare Crisium (west) at	9	42
End of eclipse	9	45

*Shooting Stars.**

Of the meteors observed simultaneously at Uranienborg, Copenhagen, and Odder in August, 1902, only ten yielded the data necessary to calculate their height above the Earth's surface. For these we have the following results:—

No.	Height at the Beginning. Kilometers.	Height at the End. Kilometers.	Real Length of the Path. Kilometers.
1	119	...	..
2	...	110	..
3	...	77	..
4	112	54	72
5	117	90	31
6	57	...	..
7	92	...	..
8	139	86	65
9	87	82	44
10	101	...	..

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* *The author sends details of observations of 44 shooting stars which were made on the nights of August 9-12, 1902.* These we have been obliged to omit.—The Editors.

FIREBALLS.

In the past year twenty-six fireballs have been seen from stations in Denmark and surrounding countries, as follows: *

No.	Time.	Beginning.	End.	Mag.	Station.	Notes.
	h m					
1	Jan. 6, 8 41 P. M.	NW.	......	....	Copenhagen ...	Train. Length, 35° to 40°.
5	10, 9 30	E. to W.	in Southern sky.	♀	Göteborg	Blue-white meteor.
7	Feb. 8, 4 45	N. to S.	in Eastern sky.	....	Hobro	A beautiful fireball appearing in daylight.
8	14, 6 11 A. M.	SE.	SW. in Southern sky.	....	32 stations in Denmark.	A large meteor exploding into five parts, with trains within a common large train. The largest fragment was as bright as *Venus*. The path, about 400 kilometers long, was traversed in 20 seconds to 25 seconds.
10	Apr. 2, 1 45	SSW.	NNE., passing zenith.	....	Copenhagen ...	Lighted up the whole region. Blue-white, exploding into four parts.
11	6, 5 54 P. M.	......	SE. 45° altitude.	....	Nyköbing S....	White meteor, seen by sunlight.
13	15, 9 10	*Denebola.*	*Perseus*, between *Pollux* and the Moon.	♀	Odder	The first 5 degrees of the train were reddish. When passing *Pollux*, the fireball exploded into two parts. Duration, 20 seconds. Observed by EMANUELA KÖHL. Also seen at other places; disappeared above the North Sea.
14	20, 10 00	......	Just East of the Moon.	1-10☾	Copenhagen....	Train 3 degrees long; duration 3 seconds.
20	Sept. 10, 11 5	......	25° altitude, SE.	♃	Kolding	The meteor was red, its train green. Path 10 degrees long.
23	Nov. 9, 5 30	NW. to SW.	in Northwestern sky.	....	Lemwig	Exploded into two, and these afterwards into several parts. Slow. Train. Also seen at Tönder, Hamburg, and other stations.

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* The details of the ten most interesting of these meteors are here given.—THE EDITORS.

A BRIEF ACCOUNT OF THE D. O. MILLS EXPEDITION TO CHILE.

By W. W. Campbell.

The D. O. Mills Astronomical Expedition from the Lick Observatory, University of California, will sail from San Francisco to-day* with destination in the neighborhood of Santiago, Chile. The work of the expedition will be largely technical, yet its purpose is to contribute to the solution of a perfectly definite problem.

It is well known that the observed positions and motions of celestial objects are influenced not only by the motions of the objects themselves, but also by motions of the observer. Not including several minor disturbances, the observer's motion is made up of three components:—

(1) That due to the rotation of the Earth on its axis. The elements of this diurnal motion are well known, and its effects can be eliminated completely from the observations.

(2) That due to the annual revolution of the Earth around the Sun. The form of the Earth's orbit is very well known, but there is at present an uncertainty of from one fourth to one half of one per cent in the size of the orbit. This introduces a slight uncertainty in the observer's speed, which is troublesome in a few cases. It is hoped that as a result of recent observations of the planet *Eros* we shall soon be able to eliminate the greater part of this uncertainty.

(3) That due to the motion of the solar system (Sun, planets and their moons) through space. The elements of this motion are not well known. In fact, a general knowledge of them constitutes one of the most pressing problems in astronomy, and it is to contribute to the solution of this problem that the Mills Expedition to the southern hemisphere has been organized.

More than 100 years ago Sir William Herschel, from a consideration of the apparent motions of the few stars then accurately observed, came to the conclusion that the solar system is moving in a straight line approximately toward the constellation *Hercules*. This was in fact one of the shrewd guesses for which HERSCHEL is justly famous. Later solutions made by other astronomers, using the steadily increasing number of observed stars, have confirmed the approximate correctness of HERSCHEL's result as to the point toward which the solar system is moving. They have, I think, without exception, located this point either in *Hercules* or in *Lyra*. Nevertheless, the various solutions leave an uncertainty of at least ten or fifteen degrees as to the direction of the motion.

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* February 28, 1903.

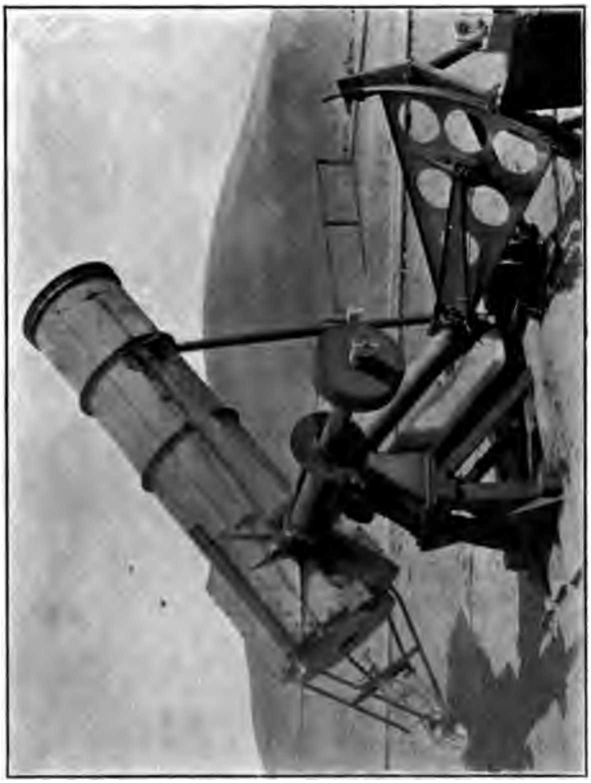
Our knowledge of the speed of the solar system has been much less satisfactory. HERSCHEL had almost no information as to the distances of the stars, but by making certain assumptions as to their distances he was led to the conclusion that the speed of the solar system is probably in the neighborhood of ten miles per second. Other discussions of the question have led to the assignment of values ranging from as low as five miles to as high as twenty-five miles per second. All these solutions were based upon the observed directions, and changes in the observed directions, of the stars, and involved assumptions as to the unknown stellar distances.

The development of the spectroscopic method of measuring stellar velocities in the line of sight of the observer has placed in our hands a means of making decided improvements in our knowledge of the solar motions, since this method is entirely independent of stellar distances. It is exceedingly simple in theory, but one of extraordinary difficulty in practice. It is based upon the fact, well known to students of physical science, that if a star is approaching the observer its spectrum will be shifted slightly as a whole toward the violet from its normal position, and if the star is traveling away from the observer its spectrum will be shifted slightly as a whole toward the red end.

These displacements of the spectra, due to the velocities of the stars, are on so minute a scale that the errors of observation may readily exceed the magnitude of the quantities to be observed. Fortunately the thorough understanding of the problem, reached through what have been bitter experiences to some observers, has made it possible at the present time to measure stellar velocities with a high degree of accuracy. The displacements of the spectra referred to, measured with the instruments now in use for that purpose, amount to only the thousandth part of an inch for a speed of fourteen miles per second. Yet we are able to measure spectrum plates very nearly to the one-hundredth part of a thousandth of an inch,— that is, nearly to the one one-hundred-thousandth of an inch. The evolution of instruments and methods and the precautions taken to enable us to reach this degree of refinement form an interesting part of the history of astronomy, but need not be considered here.

The velocities of some four hundred of the brighter stars have in the last seven years been measured with the D. O. Mills spectrograph attached to the great Lick telescope. These stars are distributed more or less uniformly over the three fourths of the sky visible from Mt. Hamilton. Two years ago I combined the results from these stars in an attempt to determine the elements of solar motion. It is evident that while the individual stars have individual motions, one moving in one direction, another in another direction, nearly all of them apparently independent of one another; yet if the solar system is moving toward a given point in the sky the stars in that portion of the sky will, on the average, appear to be approaching the solar system; and similarly, that the stars in the exactly opposite portion of the sky will appear to be moving away from the solar system. Conversely, if the velocities of the stars in all parts of the sky be known, it is possible by mathematical analysis to determine a point in the sky such that the stars within a concentric area will have the maximum velocity of approach to the solar system; and in the corresponding opposite area a maximum velocity of recession; the stars in other areas of the sky having systematically smaller speeds of approach or recession.

The solution referred to led to the result that the solar system is moving approximately in the direction of the southern boundary of the Lyre, with a speed of twelve and a half miles per second. There is no doubt that this result for speed is very close to the truth; but it is reasonably certain that the direction of the motion is somewhat in error. The weakness of the solution lies in the fact that the observed stars are not distributed uniformly over the entire sky. The region from thirty degrees south of the celestial equator to the south pole of the sky is not represented at all in the observational data.



THE D. O. MILLS REFLECTOR AND SPECTOGRAPH.

This deficiency affects the direction of motion vastly more than it does the speed. Before a satisfactory solution of this great problem can be made the stars in the one fourth of the sky around the south pole must be observed by methods similar to those employed at Mt. Hamilton.

It has for nine years past been my desire to organize at the proper time a spectroscopic expedition to the southern hemisphere for the purpose of securing these observations. Two years ago, the problems under solution and the needs of such an expedition were brought to the attention of Mr. D. O. Mills, who promptly and most generously expressed the great pleasure it would afford him to provide funds for constructing the apparatus, for employing the astronomers, and for meeting the necessary expenses.

The telescope constructed for this purpose is shown in the accompanying illustration set up on Mt. Hamilton in the rear of the observatory for adjustment and trial. It is a reflecting telescope of Cassegrain form. I may remark that in a refracting telescope, such as the great Lick refractor, the rays of light from celestial objects pass through polished-glass lenses at the upper extremity of the telescope tube, and are brought to a focus at the lower extremity, where the eye of the observer is placed.

In this reflecting telescope, the upper end of the tube is open. The rays from a star pass down the tube to its lower extremity, where they fall on a silver-on-glass mirror, 37¼ inches in diameter. Its accurately polished surface, 36½ inches in diameter, has the curve of a parabola. The beam of parallel light from a star, upon striking the mirror, is reflected back, and an image of the star would be formed in the focus 17½ feet above the mirror; but a silver-on-glass hyperbolic convex mirror 10 inches in diameter, placed 4½ feet inside the focus, and just within the upper end of the tube, intercepts the rays. This small mirror is held in place by steel webs, which occult a small portion of the light from the star, but otherwise do no serious injury. This mirror turns the rays backward through a five-inch hole in the center of the large mirror, where they are brought to a focus a short distance below the telescope-tube, exactly on the slit of a powerful photographic spectroscope. The spectroscope is held in position by a steel truss. In theory it resembles the Mills spectroscope now in use at the Lick Observatory, but in reality it embodies many new departures based upon our seven years' experience with the older instrument. When in use the spectroscope will be completely inclosed in a temperature-case of aluminum, lined with hair felt and supplied with automatic electric heating apparatus, in order that it may be maintained throughout the night's observation at a constant temperature. The photographs upon which the results depend are of such exceeding delicacy that the small range of temperature which ordinarily occurs throughout the night would, if such precautions were not taken, render them almost valueless.

The mounting of the telescope was designed in general by the writer and in detail by the San Francisco firm of HARRON, RICKARD & McCONE. It was constructed in the shops of the Fulton Engine Works at Los Angeles. The optical parts of the telescope and spectroscope are from the well-known shops of the JOHN A. BRASHEAR COMPANY, Allegheny, Pa. The instruments will be covered by a modern thirty-foot steel dome, constructed by the WARNER & SWASEY COMPANY, builders of the great Lick telescope.

The dome and instruments will be mounted on the summit of one of the low hills near Santiago, where they will remain for two or three years. It is planned to measure the velocities of three or four hundred of the brighter stars in the southern sky. The photographs will be sent to the Lick Observatory for measurement and discussion. It is confidently expected that a combination of the spectroscopic results obtained at Mt. Hamilton and Santiago will lead to a very satisfactory solution of the troublesome problem of the motion of our solar system through space.

There is little doubt that, as in the Mt. Hamilton observations, the discoveries made as by-products of the investigations will rival in scientific interest the results which comprise the main purpose of the work. One or two of these by-products may be mentioned. It was found, for example, that at least one star in seven, and probably a very much larger proportion, is attended by invisible companions. This is in addition to the companion-stars visible in ordinary telescopes and known to astronomers as double stars. For instance, the North Pole star, which has perhaps been under observation more than any other for hundreds and thousands of years, was discovered, four years ago, to have two dark, invisible companions, making it a triple system; or, counting the distant, well-known visual companion, a quadruple system.

Great interest has been taken in the plans of the Mills Expedition by astronomers and others. A recent important committee, reporting upon plans for astronomical progress, gave recognition to the fact that the Mills Expedition from the Lick Observatory would be the first to undertake observations of this kind in the southern hemisphere, and expressed the opinion that it would be well if at least one more similar expedition could be dispatched to occupy this neglected field.

The importance of this line of work and the interest taken in it may perhaps best be expressed by referring to the fact that nearly all of the great refracting telescopes of the northern hemisphere have been engaged in it with greater or less degrees of success.

The Mills Expedition will be in charge of Acting Astronomer WILLIAM H. WRIGHT, who has ably assisted in the observations with the Mills spectrograph at the Lick Observatory in the last six years, and to whose valuable suggestions and help much of the success of the work is due. Mr. WRIGHT was graduated from the University of California in 1893. He will be accompanied by Assistant H. K. PALMER of the class of 1898, who was for four years on the Lick Observatory staff as fellow, and who is at present an instructor in the Berkeley Astronomical Department.

The Government of Chile has taken official notice of the coming of the expedition, and has generously offered to further its purposes in every way possible.

D. O. MILLS has taken a deep interest in the work of the Lick Observatory since his appointment thirty years ago as a member of Mr. LICK's first board of trustees, and he has contributed to its needs on four occasions in the past decade. I confidently expect that the results obtained by the expedition to Chile will be worthy of his splendid gift and of the observatory and university under whose auspices the work is undertaken.

June 26. 10.00 P. M. Nearly equal to *a*.
28 10.00 P. M. Still nearer to the brightness of *a*.
July 1. 9.12 P. M.
4. 9.18 P. M.
7. 9.05 P. M.
9. 9.12 P. M.
10. 9.18 P. M.
12. 9.13 P. M.
16. 9.08 P. M.
21. 9.15 P. M.
22. 9.00 P. M.
29. 8.30 P. M.
Between *a* and *f*.
30. 8.40 P. M. Nearly as bright as *a*.
31. 9.30 P. M. Nearly as bright as *a*.

The continued sameness was rather unusual, but being familiar with the field of view, I feel no uncertainty about it.

Y Virginis.

1902.
April 10. It is of about 10th mag.
13. Of 9.5 mag.
24. Of 9th mag.
May 2. About 8.8 mag.
8. About 8.8 mag.
11. Of 9th mag.
12. Date of maximum.
29. 8.35 P. M. Equals *c* of 9.5 mag.
30. 8.45 P. M. Equals *d* of 10.5 mag.
31. 9.00 P. M. *d* two tenths brighter than var.
Aug. 1. 9.05 P. M. *d* two tenths brighter than var.
2. 9.00 P. M. Equal to *n* of 10.9 var.
14. 8.35 P. M. Probably not far from 12th mag., which is the usual limit of the telescope used.

W Aurigæ.

1902.
Oct. 28. Brighter than *a*, less than *c*. Probably of 9.3 mag.
Nov. 1. Brighter than *a*, less than *c*. Probably of 9.3 mag.
3. Equal to *a*.
11. Equal to *a*.
18. Fainter than *a*, brighter than *k* and *l*, with which it forms a triangle. About 10.5 mag.
22. Fainter than *a*, brighter than *k* and *l*.
26. Seems nearly equal to *a*.
Dec. 1. Less than *a*, scarcely brighter than *l* of 11th mag.
10. Equal to *k*, classed as 12th mag.
16. Invisible. This maximum of October seems to have been unexpected.

S S Cygni.

A brief maximum of this interesting star was observed as follows:—

1902.			
June	2.	9.35 P. M.	Invisible.
	24.	9.23 P. M.	
	25.	9.20 P. M.	
	26.	9.43 P. M.	
	28.	9.20 P. M.	
July	1.	9.15 P. M.	
	4.	9.21 P. M.	About 12th mag.
	7.	9.50 P. M.	
	10.	9.15 P. M.	
	12.	9.15 P. M.	
	13.	9.10 P. M.	
	15.	9.15 P. M.	Equal to *a* of 9.6 mag. Brighter than others, except *b*, in the triangular group around it.
	16.	9.05 P. M.	About two tenths brighter than *a*.
	21.	9.10 P. M.	Equal to *a*. Full moon.
	22.	9.10 P. M.	*a* two tenths brighter than the variable.
	29.	8.35 P. M.	Var. equals *c* of 9.5 mag.
	30.	8.45 P. M.	Var. equals *d* of 10.5 mag.
	31.	9.00 P. M.	*d* two tenths brighter than var.
Aug.	1.	9.05 P. M.	*d* two tenths brighter than var.
	2.	9.00 P. M.	Equal to *n* of 10.9 mag.
	14.	8.35 P. M.	It is about 11.5, or 12th mag.

S Tauri.

The minimum of *S Tauri,* expected on February 10th, occurred somewhat earlier, as at that stage it is invisible in a 4-inch lens.

1903.		
Jan.	29.	About 10.5 mag.
Feb.	1.	10.2 mag. It is slightly increased.
	10.	In moonlight it seems of 10th mag., being equal to the adjacent stars.
	12.	In moonlight it seems of 10th mag.
	19 and 24.	Brighter than 10th, of 9.7 mag.
March	3.	It is of about 9.5 mag.
	6.	About 9.5 mag. Moon near by.
	8.	About 9.5 mag. Moonlight.

R Tauri.

1902. On November 19th, December 1st, 20th, 24th, 27th and 28th, this star was invisible.

1903.
Jan. 29. Of 11th mag. Dimmer than *S Tauri* in the same field of view.
Feb. 1. About 10.2 mag., but dimmer than s.
10. 9.5 mag., brighter than s.
12. Not far from 9th mag.
19. Brighter than 8th, probably 7.8 mag.
24. Brighter than 8th.
March 3. Not so bright, probably of 8th mag.
6. Probably of 8th mag. Half moon near.
8. Probably of 8th mag. Moonlight.

S Ursæ Minoris.

1902. Date of expected maximum, May 9, 1902.
April 8. 9th mag.
9. 9th mag.
19. 8.5 mag.
26. 8th mag.
May 1. 8.5 mag.
8. 8.5 mag.
10. 8.5 mag.
14. 8.5 mag.

T Ursæ Majoris.

1902.
March 30. Equal to *k* of 9th mag.
April 8. About 8.8 mag.
13. Of 8th mag.
19. About two tenths brighter than 8th mag.
26. About two tenths brighter than 8th mag.
May 1. About two tenths brighter than 8th mag. Before the date of maximum brightness, May 21st, it had gone out of view.

PLANETARY PHENOMENA FOR MAY AND JUNE, 1903.

By Malcolm McNeill.

PHASES OF THE MOON, PACIFIC TIME.

First Quarter,	May	3,	$11^h 26^m$ P.M.	First Quarter,	June	2,	$5^h 24^m$ A.M.
Full Moon,	"	11,	5 18 A.M.	Full Moon,	"	9,	7 8 P.M.
Last Quarter,	"	19,	7 18 A.M.	Last Quarter,	"	17,	10 44 P.M.
New Moon,	"	26,	2 50 P.M.	New Moon,	"	24,	10 11 P.M.

The Sun reaches the solstice and summer begins June 22d, 7 A. M., Pacific time.

Mercury presents the best aspect of the year for naked-eye visibility during May. It is an evening star, and comes to its greatest east elongation on May 10th. It is then 21° 31′ east of the Sun, a distance about 4° greater than at the east elongation of January; but it is also several degrees north of the Sun, and this increases the interval between the setting of the Sun and the planet. For the first half of the month this interval is from an hour and a half to an hour and three quarters, and the planet can be easily seen on any clear evening in the twilight. After that *Mercury* rapidly approaches the Sun, and comes to inferior conjunction on June 3d. During the remainder of June the planet is a morning star, and comes to greatest west elongation on June 27th. It then rises rather more than an hour before sunrise, and may be seen on clear mornings shortly before sunrise.

Venus is an evening star, and sets rather more than three hours after the Sun until the latter part of June, when the interval begins to shorten up a little. The planet continually increases its apparent distance from the Sun throughout the period, but its motion eastward along the ecliptic carries it to a region of smaller declination than that of the Sun, and this, toward the close of the period, more than counterbalances the gain in distance as far as it affects the interval between the setting of the Sun and the planet. *Venus* will reach its greatest distance from the Sun early in July.

Mars passed opposition with the Sun on March 28th, and is now beginning to increase its distance from the Earth. On May 1st it sets about 3:30 A. M., on June 1st at 1:30, and at a little before midnight on July 1st. It is therefore still in fine position for evening observation. At the beginning of May it is in the eastern part of the constellation *Leo,* not far from *Denebola,* and is slowly retrograding. This westward motion is small,—only about as much as the Moon's apparent diameter, —and continues until May 10th. The planet then resumes its eastward motion, slowly at first, but by the end of June it will be about 13° east and south of its position on May 10th. In going eastward it will follow a path a little to the south of that pursued in its westward progress, and at the end of June it will be about 4° south of the position it occupied at the end of March. The path of the planet as seen from the Sun crosses the Earth's orbit-plane on June 24th, and the variation of distance from the ecliptic is most strongly marked at this time of node passage. This accounts for the fact noted above that the westward path is so far south of the eastward. The distance of the planet from the Earth in millions of miles varies from 66, on May 1st, to 84 on June 1st, and 104 on July 1st. On June 15th it is at about the same distance from the Earth as the Earth's mean distance from the Sun. The planet will still be very bright, but at the end of June its brightness will be only about one third of that at opposition.

Jupiter is a morning star, but it rises earlier, at 3 A. M. on May 1st, at 1 A. M. on June 1st, and shortly after 11 P. M. on July 1st. It is in the constellation *Pisces,* and moves about 7° eastward and 3° northward, the greater part of the distance being traversed in May. Toward the end of June the motion becomes much more slow, and it will cease about the middle of July.

Saturn rises shortly after 1 A. M. on May 1st, at about 11:20 P. M. on June 1st, and at about 9:16 P. M. on July 1st. It is therefore gradually getting to a position for evening observation. It is in the constellation *Capricorn,* and moves slowly eastward until May 20th. It then begins to retrograde, so that its position at the end of June is about 1° west of the position at the beginning of May. As seen in the telescope, the rings are not as widely open as they were a year ago, the ratio of minor to major axis being less than one third.

Uranus comes to opposition with the Sun on June 15th, and is therefore, during that month, above the horizon nearly all night. It is still in the southern extension of *Ophiuchus* between *Sagittarius* and *Scorpio,* and moves about 2° westward during May and June. Unfortunately there is no bright star near it to afford an easy means of identification.

Neptune, too faint to be seen except with a good telescope, is in the western sky in the evening during May, and reaches conjunction with the Sun on June 23d. On May 15th *Venus* passes it 3° to the north.

(FORTY-THIRD) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to M. MICHEL GIACOBINI, astronomer, Nice Observatory, France, for his discovery of an unexpected comet on December 2, 1902.

The Committee on the Comet-Medal:

W. W. CAMPBELL,
CHAS. BURCKHALTER,
WM. M. PIERSON.

(FORTY-FOURTH) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to M. MICHEL GIACOBINI, astronomer, Nice Observatory, France, for his discovery of an unexpected comet on January 15, 1903.

The Committee on the Comet-Medal:

W. W. CAMPBELL,
CHAS. BURCKHALTER,
WM. M. PIERSON.

NOTICES FROM THE LICK OBSERVATORY.*

Prepared by Members of the Staff.

The Orbit of ε *Hydræ* AB.

It has been known almost from the time of its discovery by **Schiaparelli** in 1888 that the close double star known as AB of ε *Hydræ* is a binary system in rapid motion. Measures made by **Burnham** with the 36-inch telescope in the years 1888 to 1892 showed an increase in angle of 40° in the four years. Later observations at Greenwich and, since 1898, at the Lick Observatory, gave evidence that the rate of motion was increasing, the angular change in the twelve years from discovery to 1900 amounting to 150°. But this arc was not sufficient to warrant any conclusions as to the form of the orbit, or even as to the approximate period of revolution.

In 1901 I examined this star with the 36-inch on several nights, but could see no measurable elongation. But on November 15, 1902, I found no difficulty in measuring the pair. The disks of the two components were distinctly separated, and one was sensibly smaller than the other, so that there was no doubt about the quadrant. The smaller star was in the second quadrant, as it had been at the time of discovery in 1888, and had described an arc of 200° in the three years since my measures in 1900. This result was confirmed by two measures secured in February and March of this year.

The mean of **Schiaparelli**'s measures in 1888, as given by **Burnham**,[†] is:—

1888.28	142°.0	0''.21	6^{n}

and my recent measures are:—

1902.873	126°.6	0''.17
1903.139	132 .8	0 .21
.177	136 .9	0 .18
1903.06	132°.1	0''.19

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[*] Lick Astronomical Department of the University of California.

[†] *Publications of the Lick Observatory*, Vol. II, p. 68.

Plotting these measures and those made in the intervening years, as given in Table I, I found it possible to represent them satisfactorily by an ellipse, from which, by graphical methods, I derived the following set of elements:—

$$\begin{array}{llll} T = & 1901.1 & \Omega = & 109^\circ.5 \\ P = & 15.7 \text{ years} & i = & 35\ .5 \\ e = & 0.685 & \lambda = & 264\ .7 \\ a = & 0''.24 & n = & +\ 22\ .293 \end{array}$$

These results are considered as approximate only. When further observations have been secured, some of the elements will probably require considerable correction; but, as will be seen from Table I, the observations so far published are represented satisfactorily. The two components of the system differ fully two magnitudes in brightness, and their maximum apparent separation is only 0″.25. It is therefore a difficult pair to measure, even with the most powerful telescopes.

There is a third star about 3″ distant which with the close pair forms the double star Σ 1273. The angular motion of C about the bright star has amounted to about 38° since 1830, without material change in the distance. It is thus evident that we have here a ternary system.

Still further interest attaches to this star from the fact that spectrographic observations show that its velocity in the line of sight is variable.*

At present it is not possible to say what the period of the spectroscopic binary is, but it is comparatively a long one. It is interesting to note that the plates showing the maximum velocity (+43 kilometers) were taken when the visual binary was near the line of nodes; while the plate showing the minimum velocity (+28 kilometers) was taken after the visual binary had described an arc of about 180° and was again near the line of nodes. This may mean that the visual and spectroscopic binaries are identical, but further evidence is needed to determine this question with certainty.

The table that follows gives the data on which my orbit is based, and shows the agreement between the computed and observed places. It includes all complete measures that I have been able to find, except those made at Greenwich in 1901. These measures place the smaller star in the fourth quadrant instead of the first, and hence have residuals exceeding 90°.

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* See Lick Observatory Bulletin No. 4, and *Publications* A. S. P., Vol. XIII, p. 164.

TABLE I.

Date.	θo	θc	ρo	ρc	$\Delta\theta(o-c)$	$\Delta\rho(o-c)$	Observer.	n
1888.28	142°.0	145°.7	0".21	0".23	− 3°.7	−0".02	Schiaparelli	6
1888.98	154 .4	153 .0	0 .26	0 .24	+ 1 .4	+0 .02	Burnham	2
1890.92	170 .0	170 .8	0 .19	0 .24	− 0 .8	−0 .05	Burnham	2
1892.18	179 .6	182 .3	0 .21	0 .24	− 2 .7	−0 .03	Burnham	2
1896.21	212 .0	223 .3	0 .22	0 .22	−11 .3	±0 .00	Lewis........	3
1898.14	250 .7	246 .5	0 .18	0 .20	+ 4 .2	−0 .02	Aitken	1
1899.15	261 .3	261 .3	0 .22	0 .18	± 0 .0	+0 .04	Aitken	3
1899.23	263 .5	262 .6	0 .21	0 .18	+ 0 .9	+0 .03	Lewis........	4
1899.92	274 .8	276 .2	0 .18	0 .15	− 1 .4	+0 .03	Aitken	1
1900.18	293 .4	283 .1	0 .13	0 .13	+10 .3	±0. 00	Aitken	3
1900.24	267 .2	284 .9	0 .20	0 .13	−17 .7	+0 .07	Lewis........	1
1903 06	132 .1	129 .9	0 .19	0 .20	+ 2 .2	−0 .01	Aitken	3

March 14, 1903.

R. G. AITKEN.

THE PRESSURE OF LIGHT AND HEAT AND THE EXPERIMENTAL PRODUCTION OF AN APPEARANCE RESEMBLING THE TAIL OF A COMET.

At the recent meeting of the American Physical Society in Washington, a paper* was presented by Professor E. F. NICHOLS and G. F. HULL giving the final results of their experiments upon the pressure of heat and light. With the improvements in the apparatus suggested by their early trials, very accurate results have been obtained. The observed pressures agreed *within one per cent* of those computed from theory.

The effect of wave-lengths on the pressure was tested. The pressure was found to be independent of the wave-length and to depend only upon the energy of the radiations. This is in accordance with the theory.

A very interesting application of this pressure effect was made by the investigators in the production of an appearance resembling a comet's tail. A powder consisting of a mixture of emery and puff-ball spores was placed in a vacuum-tube somewhat resembling an hour-glass. The exhaustion of the tube was made as perfect as possible, and especial care was taken to get rid of any mercury vapor. When the powder was poured from one portion of the tube to the other and an arc-light directed upon it at the same time, the lighter portions of the powder were repelled, producing an appearance closely resembling the tail of a comet. The effect was comparable with what was to be expected from the energy observed. The authors considered it possible that the phenomena might be produced in part by other causes. In any event, the experiment reproduced with great accuracy the appearances observed in the tails of comets.

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* "Pressure Due to Radiation." In the account of the meeting in *Science* of January 30, 1903.

This work of NICHOLS and HULL points the way to other investigations which should throw much light on the vexed question of the constitution of the comets. C. D. P.

NOTES ON THE THREE COMETS NOW VISIBLE.

Comet a 1903: The telegram announcing the discovery of a new comet by M. GIACOBINI at Nice was received at the Lick Observatory on January 20th, but continuous stormy weather prevented observations here until the evening of January 29th. As seen with the 12-inch telescope on that date, the comet appeared to be about as bright as a ninth-magnitude star. It was small, nearly round, and with only a feeble condensation. During the month of February the comet grew steadily brighter and larger, and the condensation in the coma became more sharply defined, appearing at the time of the last obsrvation as a bright disk about $2''$ or $3''$ in diameter. On February 15th, a faint straight tail was visible to a distance of about $5'$ in the north-following quadrant. This has grown brighter and longer, being traced to a distance of more than one degree in position-angle 47° on February 25th. When last seen the comet as a whole was as bright as a 6.5-magnitude star.

Comet d 1902: Observations secured here during February show that this comet is following very closely the orbit given in No. 88 of these *Publications* (p. 27). The residuals at the date of my last observations (February 28th) were only $-0^{s}.6$ and $+9''$. The comet's appearance has changed very little, though it is perhaps fainter than at first. It is still measurable with the 12-inch telescope, and can probably be followed with large telescopes for a month or two more. With one exception its perihelion distance is greater than that of any other comet so far found.

Comet b 1902: Perrine's comet was last observed here before its perihelion passage on November 17, 1902. After passing the Sun the comet was visible only to observers in the southern hemisphere until late in January, 1903. On the 29th of January, I found the comet close to the place predicted by Strömgren's ephemeris, the observed data being:—

Jan. 29, $12^h\ 57^m\ 38^s$ Mt. Ham. M. T. $\alpha = 9^h\ 5^m\ 53^s.99$
$\delta = -\ 41^\circ\ 0'\ 55''.7$

Since then the comet has moved rapidly north and west, passing close to *Sirius* in the latter part of February. On February 28th it was still visible in the 3-inch finder, and the 36-inch showed a faint nucleus.

Stormy weather has prevented observations of any of these comets since February 28th.

March 16, 1903. R. G. Aitken.

ASTRONOMICAL TELEGRAMS.

(Translations.)

Cambridge, Mass., Jan. 20, 1903.
To Lick Observatory: (Received 8:30 A. M.)

A comet was discovered by Giacobini at Nice on January 15th. It was observed at Nice on January 19.2498 G. M. T., in R. A. $22^h\ 57^m\ 48^s.0$; Decl. $+2^\circ\ 17'\ 36''$. The daily motion is east 17′, north 12′. (Signed) E. C. Pickering.

Boston, Mass., Jan. 22, 1903.
To Lick Observatory: (Received 8:30 A. M.)

Comet *a* 1903 (Giacobini) was observed by Dinwiddie at Washington, on January 21 4915 G. M. T., in R. A. $23^h\ 0^m\ 6^s.5$; Decl. $+2^\circ\ 47'\ 46''$. (Signed) John Ritchie, Jr.

CAMBRIDGE, MASS., Jan. 26, 1903.

To Lick Observatory: (Received 10 A. M.)

Kiel cables the following elements and ephemeris of Comet *a* 1903:—

T = 1903, March 24.81 G. M. T.

$$\left.\begin{array}{lrr} \omega = & 133^\circ & 37' \\ \Omega = & 2 & 32 \\ i = & 30 & 30 \end{array}\right\} 1903.0$$

nat. $q = 0.4085$

Brightness on Jan. 25 = 1.46, on Feb. 6 = 2.64.

(Signed) E. C. PICKERING.

[The ephemeris at 4-day intervals from January 25th to February 6th is here omitted.]

CAMBRIDGE, MASS., Jan. 26, 1903.

To Lick Observatory: (Received 1 P. M.)

SEARES telegraphs that he observed Comet Giacobini on January 25.5643 G. M. T., in R. A. $23^h\ 4^m\ 38^s.3$; Decl. $+3^\circ\ 48'\ 16''$. (Signed) E. C. PICKERING.

REPORTS OF OBSERVATORIES.

ASTROPHYSICAL OBSERVATORY OF THE SMITHSONIAN INSTITUTION.*

During the past year the acquisitions of property have been as follows: *Apparatus.*—Astronomical and physical apparatus has been purchased at an expenditure of $2,000. *Library and Records.*—The library has been enlarged by the addition of periodicals and books of reference at an expenditure of $200. Books and periodicals have been bound at an expenditure of $250. Total for library, $450.

The Solar-energy Spectrum.—The early work of this Observatory described in Volume 1 of its Annals was chiefly concerned with the minute absorption bands in the intra-red solar spectrum; automatic prismatic energy curves were made by the aid of the bolographic process, and such inflections of these curves as were found not accidental in their origin corresponded to the so-called Fraunhofer lines of the visible spectrum. Less attention was paid to the whole height of these curves at their various parts than to these numerous small variations in height.

The Absorption of the Atmosphere and of the Solar Envelope.—This present year care has been taken to obtain energy curves whose heights shall be comparable. It was the purpose of this work to study the general absorption of the sun's envelope, the general absorption of the earth's atmosphere, and the changes in the selective absorption of water vapor in the latter. It is the further object toward which these studies tend to see if the Sun is constant or variable in its output of radiation. While the results of the past year indicate possibility of considerable ultimate success in this final object, it may probably prove that the situation of this Observatory is unsuitable to the most exact studies of this kind, owing to the great and variable absorption of the air column above it, as well, of course, as to the ground tremors inherent in its present site, surrounded by the traffic of city streets. It seems certain, however, that valuable contributions to the methods of study to be adopted in work at more favorably situated stations, and to the knowledge of terrestrial absorption, can be made here.

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* Condensed, with permission, from "Report of the Work of the Astrophysical Observatory for the year ending June 30, 1902, by C. G. Abbott, *Aid Acting in Charge.*"

Absorption of the Atmosphere and Selective Absorption of Water Vapor.—Since January 20th all favorable opportunities have been used to take quick-speed energy curves. These have been made with quite different altitudes of the Sun. Sometimes as many as 15 have been taken in one day, and 160 were secured between January 20th and July 1st. These curves are studied from two points of view: first, as regards the variation in height for single wave-lengths with different altitudes of the Sun; second, as regards the variation in area and especially the areas of the great regions of water-vapor absorption. The first kind of examination leads to the determination of the general absorption of the air, the second to fixing the variations in amount of the solar radiation and of the special selective absorption of water vapor.

To illustrate the first method of study, let us suppose several energy curves to have been taken in a single clear day, during which the barometer height was (B), and let (B_0) be the standard barometric height, generally taken as 76^{cm}. From the altitudes of the Sun as computed from the hour angles and declination, the air mass (m) is determined. This quantity represents the ratio which the mass of air traversed by the solar beam bears to that mass of air which would be traversed if the Sun was directly overhead. If we suppose (e) to represent the amount of radiant energy per square centimeter of a certain wave-length which reaches the Earth's surface, and (e_0) the amount prior to absorption by the Earth's atmosphere, and let (a) be the proportion transmitted per unit air mass, then by the well-known formula of BOUGUER:—

$$e = e_0 a^{m \frac{B}{B_0}}$$

But since the height (d) of the bolographic energy curve at the wave-length in question is proportional to (e), we may write:

$$d = ke = ke_0 a^{m \frac{B}{B_0}}$$

where (k) is an instrumental factor connected with the width of the slit, the absorption of the optical surfaces, the quality of the bolometer, and the sensitiveness of the galvanometer. We may assume (e_o) and (k) to be constant for the short space of time occupied by one day's observations. We then obtain the following equation:—

$$\log (d) = m \frac{B}{B_o} \log (a) + \log (ke_o)$$

of which the last term is constant. This equation is in the form of the equation of a straight line, so that if we make a plot in which heights are proportional to logarithms of (d), and horizontal distances to values of ($m \frac{B}{B_o}$), the various observations should determine a straight line the tangent of whose inclination is the quantity log. (a). The procedure has been followed with many of the energy curves already taken.

Absorption of the Solar Envelope.—The experiments on the absorption of the solar envelope briefly mentioned in last year's report were continued as far as practicable with the apparatus available.

Personal-equation Machine.—You* have placed at the Observatory for trial an instrument of your own design intended to eliminate the so-called personal equation of individual observers in transit observations. The principle of this instrument consists in substituting a judgment of the place where a sudden phenomenon occurred for the time when it occurred. To use an illustration which you have already employed, in case the dark field in which only the star is seen moving were illuminated every two seconds by a self-recording flash which showed the central wire, and if by pure accident the star was caught in an exact bisection when the flash came—an accident against which the chances are perhaps more than a hundred to one—it is evident that in this rare and improbable event there would be no personal equation to allow for, if the time of flash within two seconds were noted by the observer. Now, the object of the following mechanism may be said to be to make this accident happen every time.

This being understood, as first tried with the apparatus which you furnished, the design was to illuminate the cross-wires of the transit instrument by automatically recorded electric flashes occurring at regular intervals equal to the time elapsing between passages of the star across successive wires. An adjustable mechanism allowed the observer to hasten or defer the whole system of flashes until by successive adjustments he caught the exact instant when the star was bisected by the dark wire in the instantaneously bright field. Several such adjustments could be made during a single star transit across the numerous wires of the tally, and immediately after each satisfactory bisection a signal was made on the chronograph by a key in the hand of the observer, so that only such recorded flashes as were thus distinguished were used in determining the time of transit.

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* This report is addressed to Professor S. P. LANGLEY, Secretary of the Smithsonian Institution.

In order to test the value of this instrument an artificial star was caused to move through the field at a rate about equal to that of a real equatorial star. This star was moved by a screw and clockwork of great accuracy, and always through the same portion of the screw. It was also provided that when the star was exactly bisected by the middle wire an electrical contact was broken, so that the star recorded its own transit upon the chronograph. The adjustment of the contact for this bisection was made at leisure with the star stationary, and was therefore not subject to the personal error of transit observations. Accordingly, after determining all the wire intervals, it was entirely easy to measure the personal equation of the observer, whether he used the personal-equation machine or the ordinary method, merely by comparing his observed time of transit with that recorded by the star itself. Upon trial it was found that the personal equation of the several observers was not wholly prevented by employing the machine in the manner described; that is, by bisections judged during instantaneous flashes. The writer, for example, observed about 0.12 second too early by both methods.

It seemed probable that the observer was still biased in his judgment by watching the march of the star through the field across the very faintly showing wires, which are always to be made out by the stray light of the star and sky, even though there is no illumination by the flash. Accordingly it seemed to promise success to alter the arrangement so that the star would be hidden except at the instants corresponding to those when the flash had formerly appeared, and to steadily illuminate the field as is usual in transit instruments. In the test this was easier than in actual practice, for the artificial star itself could be obscured by a shutter immediately in front of it, which could be removed instantaneously by the electric signal from the personal-equation machine. The same thing could, however, be done at the focal plane of the telescope in real use.

Upon trial this device justified all hopes. Three observers whose habit is to observe, one too early, one too late, and the other very close to the true time, were found all to observe as close to the truth as the accidental errors would admit, which in the case of the 3-foot focus transit instrument employed was generally within 0.03 second. In other words, personal equation seems to be wholly eliminated by this procedure. The general design may be applied without great expense to any outfit of transit and chronograph.

Experiments on "Boiling" of the Image.—I add a few words, partly in anticipation, in reference to your newly-introduced device for preventing the well-known effect of "boiling" of the telescopic image, a difficulty due to the Earth's atmosphere and which has existed always and everywhere, and which has seemed until lately so insurmountable that it has not even been thought of as subject to correction. The device that you have suggested consists essentially not in keeping the air still within and without the telescope tube, but in violently agitating it over as great a range as possible. For this purpose, under your instructions and with the object of rehearsing on a small scale what, if the device is successful, will be later tried on a large one, a silvered-glass mirror of five inches diameter and forty feet focus has been set up in a tube with several concentric walls, so as to leave the interior air as still as possible. In preliminary experiments the air, in spite of these precautions in the installation, gave such "boiling" of the image as to seriously prejudice the definition, and this, although the forty-foot tube had no less than three walls, being seven inches in interior diameter and fifteen inches in exterior diameter, and inclosing the beam all the way from a second plane mirror near the cœlostat to the concave mirror and thence to the focus. Though this tube containing the stillest air of the most uniform temperature was sheltered throughout by a canvas tent, the "boiling" was but a little diminished. Nothing was gained by diminishing the aperture of the several mirrors down to one inch in diameter, and all this was only what had been anticipated from the ordinary experience of astronomers. A twelve-inch blower run by an electric motor was now caused to exhaust air from the inner tube at a half-dozen points along the tube, and to force air in at other points alternate with these, so as thus violently to disturb or "churn" the air by forcing a vigorous circulation of it along the whole path of the beam from the cœlostat to the solar image. This unquestionably reduced the "boiling." An artificial star was now provided at the focal plane, the plane mirror near the cœlostat was placed at right angles to the tube, and thus the concave mirror, acting as both collimator and objective, brought the star-image to focus at the star itself. Here it was examined with an eye-piece. With still air the definition was often very poor. The image assumed very variable shapes, with wings or streamers; and being also colored by diffraction effects, reminded one of a kaleidoscope field. On starting the blower the definition immediately became sharp. Violently stirring the air in the tube, therefore, eliminates the "boiling" within the tube and (paradoxically) produces a still image. As before said, the solar image was clearly improved by the stirring; but further improvement was still to be desired. Accordingly a tin tube forty-four feet long, with two walls of eleven inches interior diameter and sixteen inches exterior diameter, was provided and arranged to point toward the Sun, so that the beam passed down through it before reaching the mirror system. This tube was connected to the blower exactly like the horizontal one, and both could be stirred at once. There was a very marked "boiling" before starting the blower. This nearly disappeared while the blower was running. One observer estimated the "boiling" as four-fifths overcome; another thought little more than a quarter remained, and all were unanimous that what was left was very little prejudicial to the definition. This last result is so surprising that I feel constrained to add that the experiments so far are not exhaustive, having been carried on but a short time, and without that solidity of piers which would allow of exact estimate or photographic determination of the "boiling" of the solar image before and during agitation of the air in the tube, as distinguished from mechanical jarring. Further experiments are in progress. That agitation is of very great advantage to diminish "boiling" there is no question, but the exact measure of the advantage for all circumstances of bad seeing requires further study. Incidentally, the air blast has the added advantage of keeping the mirrors at uniform temperature. This and the abolishment of "boiling" in the tube are found to prevent those vexatious changes of focus so common in solar work.

Radiation of the Cuban Firefly.—In continuance of your observations on the cheapest form of light, two specimens of the Cuban firefly were loaned by the Agricultural Department. The radiation of the thoracic-light regions of these insects was briefly studied by the aid of the bolometer and photometer. A comparison of the light and heat of the standard sperm candle with that of the firefly showed the latter to be more than 10,000 times more economical as a source of light.

Personnel.—The observing-staff has been unchanged with the following exceptions: Dr. C. E. MENDENHALL was employed as temporary assistant up to August 3, 1901, and Dr. N. E. GILBERT as temporary assistant, beginning June 16, 1902.

LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA.

ORMOND STONE, DIRECTOR

Among the recent researches undertaken at the Leander McCormick Observatory, is an investigation of the standards of faint stellar magnitudes in co-operation with the Harvard, Yerkes, and Lick observatories, to be followed by a study of the more important long-period variables. The former work was done principally by Mr. H. D. CURTISS (Ph. D., 1902), now of the Lick Observatory; in the latter Professor STONE is assisted by Mr. PADDOCK, one of his present students.

LOWELL OBSERVATORY, FLAGSTAFF, A. T.

A little more than a year ago, an efficient modern spectrograph, designed and built by JOHN A. BRASHEAR, of Allegheny, Pa., was added to the equipment of the observatory. The attachment of this instrument to the twenty-four-inch refractor necessitated the enlargement of the dome. This work was begun in December, 1901, and completed in March of the following year. During this period, when possible, the telescope was used in measuring star-disks.

Since that time, after the completion of the adjustments of the spectroscope, the twenty-four-inch refractor was devoted to the photographing of stellar spectra for motion in the line of sight, until August. Since then, the time has been divided between stellar and planetary work. Successful spectrograms have been obtained from *Uranus, Jupiter, Saturn, Mars, Venus,* and the asteroid *Vesta.*

During the last part of the year considerable time has been given to visual observation of planets, chiefly *Mars.*

January 31, 1903. V. M. SLIPHER, *for Observatory.*

THE CHAMBERLIN OBSERVATORY OF THE UNIVERSITY OF DENVER.

During the first six months of 1902 no observations were made with the twenty-inch telescope, because the time of the observers was otherwise filled. But some minor repairs and alterations were made in the instrument.

In July Dr. CHARLES J. LING began a search for *Eros,* which culminated in its visual rediscovery early in August. From September on observations of comets and of *Eros* have been made.

February 7, 1903. H. A. HOWE, *Director.*

GOODSELL OBSERVATORY OF CARLETON COLLEGE, NORTHFIELD, MINNESOTA.

The research work of this observatory is at present devoted almost exclusively to solar and celestial photography. A few micrometric observations of double stars and comets are made with the sixteen-inch refractor on nights unsuitable for photography. Daily photographs of the Sun have been taken whenever possible since 1889. The approximate measures of the photographs taken from 1889 to 1893 were published last summer in *Publication* No. 3 of Goodsell Observatory.

There are on hand something like 1,200 solar photographs taken since 1893, which have not been measured because of the lack of the necessary funds for assistance, the time of the two professors being fully occupied with their duties in the instruction of the college classes, and the work of editing "Popular Astronomy."

So far as his strength would permit, Professor WILSON has given his time on the moonless clear nights to long-exposure photographs with the eight-inch Clark refractor, the six-inch Brashear star-camera, and the 2½-inch Darlot camera. These three instruments are on the same mounting and are guided by means of a five-inch telescope fastened rigidly to the eight-inch and of the same focal length with it. Most of the photographs have been of four or eight hours' exposure, the latter requiring two nights. The most successful one of the *Andromeda Nebula* received twelve hours' exposure, requiring four nights' work. The longest attempted exposure with the eight-inch was one of seventeen hours on the *Pleiades,* which failed because of imperfect backing of the plate, but the details shown on parts of the plate showed that the limit of useful exposure with this instrument had by no means been reached. With the smaller instruments the exposure has seldom been prolonged beyond eight hours, and that with the 2½-inch lens was usually stopped with one night, its construction being such that there was danger of shifting the plate on inserting the slide. A number of the photographs taken with the cameras indicate the existence of large regions of very faint nebulosity, those covering large portions of the constellations *Orion, Taurus,* and *Scorpio* being the most notable. They are so faint that very careful development is required to bring them out upon the plates, and prints can be made only from intensified copies. They require, too, the most transparent atmosphere.

During the past six months our time for research work has been devoted wholly to the measurement and reduction of the photographs of *Eros* taken during the parallax campaign of the winter 1900-1901. By the aid of a grant of $300 from the Gould Fund and the loan of the Repsold measuring-machine belonging to the University of Minnesota, we were enabled during the summer to measure sixty-six out of the seventy-four *Eros* plates, the others being too defective for measurement. The number of comparison-stars, of the list published in circulars numbers 8 and 9 of the "Conference Astrophotoappeared in 1900 as Volume I of the *Publications of the Yerkes Observatory.* Since that time he has confined his attention to a carefully selected list of stars, consisting mainly of long-neglected and little-known pairs. Many of these, taken from the catalogues of Sir WILLIAM HERSCHEL, Sir JAMES SOUTH, and other astronomers at the end of the eighteenth and beginning of the nineteenth centuries, have never been observed since that time. The list also includes many pairs recorded in various journals and observatory publications during the last fifty years which have been insufficiently observed or not measured at all. Among the other neglected pairs are those in which the evidence of decided change is of a somewhat doubtful character. These have been reobserved, and the supposed change shown to be real in some instances, but due to errors of observation in others. For special reasons some of the Σ and β stars have been measured, with others from the Astronomische Gesellschaft catalogues. Altogether some 600 of these objects are given in a paper which will appear soon in Volume II of the *Publications of the Yerkes Observatory.* As Professor BURNHAM's object has been to avoid duplicating work done elsewhere, he has placed no star on the working-list which would be likely to be measured at any other observatory.

General Micrometric Observations (Professor BARNARD).—Professor BARNARD has continued his work on the satellite of *Neptune,* which he has had under observation for several years. He has also obtained several valuable series of measures of the fifth satellite of *Jupiter.* His measures of 61^1 *Cygni,* for the purpose of redetermining its parallax and testing the conclusions of WILSING, were continued during the year and are now in process of reduction. Professor BARNARD's most extensive investigation with the forty-inch refractor has been a systematic micrometrical survey of between 600 and 700 small stars in the globular clusters *M* 3, *M* 5, *M* 13 and *M* 92. In the course of this work he has compared his measures of a large number of stars in *M* 13 *Herculis* with Professor SCHEINER's measures of the same stars, made on photographs taken at Potsdam in 1891. The comparison shows that the photographic and visual measures in general agree very closely, though there are a few discordances, amounting to one or more seconds of arc. Apparently these are not due to motion in the stars, but rather to the difficulty of making the photographic measures in the case of defective images. In the period of ten years there does not appear to be any certain proof of motion in any of the stars under observation. In the course of the work on clusters Professor BARNARD has given special attention to some of the variable stars in *M* 5 *Libræ,* for which he has determined accurate periods. In addition to the work here mentioned, Professor BARNARD has done a large amount of miscellaneous work with the forty-inch telescope, including micrometric observations of planetary nebulæ; a few double stars, such as *Procyon;* determinations of the position and focus of *Nova Persei,* etc. The measures of the *Nova* gave no evidence of a parallax. Up to August, 1902, long after the spectrum of the *Nova* had changed to that of a planetary nebula, it was found to have the same focus as that of a neighboring star. The change of focus, which was noted in September, 1902, has been described in the *Astrophysical Journal.*

Velocity of Stars in the Line of Sight (Professor FROST and Mr. ADAMS).—The Bruce spectrograph, which was completed in the instrument-shop of the observatory early in 1902, has given most satisfactory results. None of the difficulties encountered with the old three-prism spectrograph have appeared in the new instrument, and the degree of precision fully equals, if it does not surpass, the highest reached elsewhere. The twelve lunar spectra photographed during the year, for the purpose of testing the adjustment and trustworthiness of the spectrograph, gave a mean difference of 0.2^{km} per second between the observed and the computed radial velocity of the Moon, the largest difference being 0.7^{km} per second. The titanium spark was chiefly used for furnishing the comparison spectrum, but the iron and chromium spark and a helium tube were also employed at times. The principal piece of work during the year was the measurement of the radial velocities of stars having spectra of the *Orion* type. These spectra are not adapted to very accurate measurement, as the lines are comparatively few and are generally hazy and ill-defined. In spite of this fact, the results have proved fairly accordant. The lines commonly present and measured were those due to one or more of the following elements: helium, oxygen, silicon, nitrogen, hydrogen, magnesium. In a paper to appear shortly the *Publications of the Yerkes Observatory*, the detailed esults of the investigation of the radial velocities of twenty tars will appear. The velocities found for these stars, exressed in kilometers per second, are given below:—

γ *Pegasi*	+ 5.4	ε *Can. maj.* ...	+ 27.2
ζ *Cassiopeiæ*	+ 2.9	η *Leonis*	+ 3.5
ε *Cassiopeiæ*	— 5.9	γ *Corvi*	— 7.0
ζ *Persei*	+ 22.1	τ *Herculis*	— 12.7
β *Orionis*	+ 20.7	ζ *Draconis*	— 14.4
γ *Orionis*	+ 18.0	ι *Herculis*	— 16.4
ε *Orionis*	+ 26.7	67 *Ophiuchi*	— 3.1
ζ *Orionis*	+ 18.3	102 *Herculis*	— 10.8
κ *Orionis*	+ 17.1	η *Lyræ*	— 9.1
β *Can. maj.*	+ 32.6	ε *Delphini* ...	— 26.2

Many of these stars are near the apex or anti-apex of the Sun's way, and if corrected for the solar motion the resulting absolute radial velocities would be small. In the course of the year six spectroscopic binaries were discovered, and have been made the subject of special investigations. An orbit for one of these binaries, η *Orionis*, has been computed by Mr. ADAMS.

Through Professor FROST's initiative an important co-operative movement, participated in by the principal observatories engaged in investigations of radial velocity, has been set on foot. This involves the systematic measurement of the radial velocities of certain standard stars, selected with particular reference to their suitability for measurement. The results of this work will give for the first time a reliable means of determining systematic errors in investigations of radial velocity.

The Spectra of Stars of Secchi's Fourth Type (Professor HALE, Mr. ELLERMAN, and Mr. PARKHURST).—An investigation of the spectra of red stars of SECCHI's fourth type was completed during the year. Some 250 photographs, made with a three-prism spectrograph attached to the forty-inch refractor and the two-foot reflector, ranging in exposure time from a few minutes up to twenty-five hours, were obtained in the course of this research. A special study has been made of eight stars, in whose spectra the wave-lengths of several hundred bright and dark lines have been measured. The bright lines have not been certainly identified, but the dark lines have been found to be due to iron, titanium, and various other substances. They have also served for the determination of the radial velocities of the stars. Low-temperature lines, particularly those calcium, are very conspicuous in these spectra. In many cas the more conspicuous dark lines seem to correspond with lin which are widened in the spectra of sun-spots, but this cann be made the basis of any theoretical conclusions before furth investigations with higher dispersion have been made.

Solar Observations (Professor HALE, Mr. ELLERMAN, an Mr. BARRETT).—The programme of solar work prepared fc the Yerkes Observatory includes systematic investigatio along the following lines:—

1. Direct Photography: Daily photographs of the Sun o a scale of seyen inches to the solar diameter; large-scale photc graphs of spots and other regions.

2. Monochromatic Photography: Daily photographs wi the spectroheliograph, for systematic study of the form, are distribution, and motion of the calcium vapor on the disk a in the chromosphere and prominences. Comparative phot graphs in various bright and dark lines and other special searches.

3. Daily photographs of the spectrum: (*a*) of sun-sp for the systematic study of the positions and intensities of widened lines and the bright H and K lines; (*b*) of vari regions of the photosphere, for the study of the bright H and lines and the detection of possible changes in the position intensity of dark lines; (*c*) a special series of photogra taken at the shortest practicable time intervals, near the su spot maximum, in order to register, if possible, such remar able changes in the reversing layer as were recorded on a sing plate taken at Kenwood in 1894.

4. Special researches, radiometric, visual, and photographi on the spectrum of the reversing layer and the chromosphe with a large solar image and powerful grating spectroscop

5. Investigations on the solar rotation, determined with th spectroheliograph and by spectrographic observations of th photosphere, spots, chromosphere, and prominences.

6. Radiometric investigations of various kinds.

7. Visual observations to supplement those made phot graphically.

Through unavoidable delays in the construction of t necessary instruments, some of these investigations are not in progress. At present the direct photographs of the Sun are being taken daily with the twelve-inch refractor, which gives a solar image two inches in diameter. In a short time, however, this work will be transferred to the forty-inch telescope, which gives a seven-inch image. The large spectroheliograph constructed for the forty-inch telescope, in spite of its great size and weight, and the special mechanical arrangements required for its operation, has yielded excellent results after a large amount of experimental work. The slits of this instrument are eight inches long, permitting the seven-inch solar image given by the forty-inch telescope to be photographed in monochromatic light. When the construction of the cœlostat reflector had been decided upon, it was thought best to transfer the spectroheliograph from the forty-inch telescope to this instrument. But the delay occasioned by the injury of the latter instrument by fire has caused us to resume the work with the large telescope, and a daily series of photographs is now being secured with the large spectroheliograph. Excellent photographs have been obtained with the remodeled Kenwood grating spectrograph of the widened lines in the spectra of sun-spots, and many of these have been measured. Various special studies have also been made of the spectrum of the chromosphere. The large size of the solar image given by the forty-inch telescope renders it particularly suitable for this work.

Photography of the Moon, Nebulæ, and Star Clusters (Mr. Ritchey).—Mr. Ritchey's successful adaptation of the forty-inch visual refractor for photography by the use of a color-screen and double-slide plate-holder has made it possible for him to obtain many important photographs of the Moon, nebulæ, and star-clusters with the large telescope. When compared with similar photographs taken with the largest photographic refractors, these results appear to surpass in sharpness any previously obtained. The simplicity and cheapness of the color-screen method, and the ease with which it can be applied to existing visual telescopes, will recommend it to those who are not provided with photographic telescopes. In the lack of a measuring-machine, which will be supplied in the immediate future, it has not been possible to make a careful study of the distortion of the negatives produced by the color-screen. There seems to be no doubt, however, that this is of such a character that it can easily be allowed for.

The excellent results obtained by Mr. RITCHEY in photographing the nebula surrounding *Nova Persei*, as well as various other nebulæ and star-clusters, with the two-foot reflector recently constructed in the observatory shops, have demonstrated that work of great importance can be done with a properly constructed reflecting telescope of comparatively small aperture. There can be no doubt that the development of reflecting telescopes during the last fifty years has been greatly retarded by the insufficient attention given to the mechanical design and construction of the mountings. The excellent photographs obtained with the Crossley reflector by Professor KEELER and Mr. PERRINE indicate that with sufficient skill and persistence some of the older instruments may yield good results, but with suitably designed mountings most of the difficulties experienced in this work disappear. The remarkable photographic efficiency of the reflector is shown by the fact that stars at the limit of vision with the forty-inch refractor can be photographed with the two-foot reflector in forty minutes. With longer exposures innumerable stars, one or perhaps two magnitudes fainter than those at the limit of the forty-inch, can be photographed. As there can be no doubt that larger reflectors, when used under good atmospheric conditions, will produce proportionately better results, it is hoped that means may soon be found to mount the five-foot mirror made by Mr. RITCHEY in the optical shop of the Yerkes Observatory.

Photometry (Mr. PARKHURST).—For some time past the Yerkes Observatory has been co-operating with the Harvard, McCormick, and Lick observatories in the work of determining standards for faint stellar magnitudes with a wedge photometer supplied by the Rumford Committee of the American Academy of Arts and Sciences. Mr. PARKHURST has made a careful series of determinations of the wedge constant by the method of standard stars and also with a wheel photometer. The wedge photometer has been systematically used with a six-inch reflector and with the twelve-inch and forty-inch refractors. In addition to the observations of faint standards made with the forty-inch telescope, which have been fewer than was hoped on account of the unusually bad weather and the small amount of time that could be spared from other investigations, Mr.

PARKHURST has photographed many of the fields containing the standards with the two-foot reflector. Paper prints of these show stars down to the seventeenth magnitude or fainter, and render the identification of the faint standards certain, a work equally important with the photometric measures themselves. In addition to this photometric work, Mr. PARKHURST has continued his observations of variable stars, giving special attention to those which are exceedingly faint at minimum.

Spectroscopic Laboratory (Professor HALE and Dr. KENT). —During the year the equipment of the spectroscopic laboratory has been greatly increased, and now includes a six-inch concave grating spectroscope of 21½ feet focal length, with smaller concave gratings for special purposes; a 3 K. W. 110-volt alternating dynamo, presented by Dr. GEORGE S. ISHAM*;* a 1 K. W. transformer, giving 15,000 or 30,000 volts; various induction coils, including a high-frequency coil presented by Mr. JAMES LYMAN; a large condenser, volt-, watt-, and ammeters, and other apparatus presented by Dr. ISHAM; and various miscellaneous instruments. The various light sources, including the arc in air, rotating arc in liquids, spark in air at various pressures, spark in liquids, etc., are arranged on the circumference of a circular table, at the center of which is a plane mirror. By means of this mirror the light from any source can be reflected to a large concave mirror, which forms an image of the source on the slit of the concave grating spectroscope in the adjoining room. To pass from one source to another it is only necessary to rotate the plane mirror. This arrangement has proved very convenient in practice, and is believed to eliminate the danger of such displacements of lines as sometimes occur when an adjustable image lens is used in front of the slit.

The principal work of the spectroscopic laboratory during the year has been an investigation on the spark spectra of iron and other metals in liquids and in air at high pressures, in connection with solar and stellar spectra. By changing the constants of the discharge circuit, or by varying the pressure of the air in which the spark is observed, it has been found possible to pass by successive steps from a bright line spectrum to one consisting almost wholly of dark lines in the ultra-violet. The reversals appear first in the ultra-violet and gradually advance toward the less refrangible region, thus reproducing the effect observed by Professor CAMPBELL in certain stars, whose spectra contain dark hydrogen lines in the ultra-violet and bright ones in the less refrangible region. A careful study has been made of the displacements of the lines which accompany the changes of the absorption phenomena, and these are being discussed with reference to their bearing on the spectra of temporary stars.

Cœlostat Reflecting Telescope.—In view of the excellent photographs of the corona obtained by Professor BARNARD and Mr. RITCHEY at the eclipse of May 28, 1900, with the aid of a cœlostat constructed in the observatory shops, it was decided to build a much larger cœlostat, to be used with concave mirrors of various apertures and focal lengths for astronomical photography and for spectroscopic observations requiring the use of large-grating spectroscopes mounted under laboratory conditions. The cœlostat, which had a mirror of thirty inches aperture, was completed with the aid of grants from the Rumford and Draper Funds in the autumn of 1902. Light from the cœlostat mirror was reflected to a second plane mirror of twenty-four inches aperture, which sent the rays in a southwesterly direction to a concave mirror of sixty-two feet focal length. This mirror returned the rays and formed the image near the cœlostat. All parts of the apparatus, including the mirrors, were made in the observatory shops under the direction of Mr. RITCHEY. For direct photography a double-slide plate-holder was to be used. For photographic work on the spectra of some of the brightest stars there was provided a concave-grating spectrograph, having a six-inch grating ruled by Mr. JEWELL on Professor ROWLAND'S engine for this research, used in conjunction with a collimating lens of five inches aperture and thirteen feet focal length. This was mounted on solid piers in a double-walled room, arranged with automatic apparatus to maintain a constant temperature. When in process of adjustment, the insulation of the wires connected with the comparison-spark apparatus broke down, setting fire to the walls of the room. A high wind was blowing, and it was impossible to extinguish the flames, which destroyed the spectrograph house and the building containing the cœlostat and mirrors. The twenty-four-inch plane mirror was saved, and most of the heavier parts of the apparatus were not injured. The reconstruction of the instruments is going on rapidly in the Observatory shops, and it is hoped that they may be in use during the summer of 1903.

Bruce Photographic Telescope.—A ten-inch photographic objective of the portrait-lens type, having a focal length of fifty inches, was completed by BRASHEAR and thoroughly tested by Professor BARNARD during the year. There has been great delay in securing a suitable objective, on account of the difficulty of obtaining a sufficiently large field. With the present lens, used with a plane plate, it is expected that good definition will be obtained over a field about 9° in diameter. This will be extended to 12° by the use of a curved plate. WARNER & SWASEY have made designs for the mounting, and it is hoped that the instrument will be ready for use in the summer of 1903.

Publications.—Volume II of the *Publications of the Yerkes Observatory,* containing papers by Messrs. BURNHAM, BARNARD, MOULTON, FROST, and ADAMS; HALE, ELLERMAN, and PARKHURST; RITCHEY; and LAVES, will be published within a few months. Observatory bulletins are now issued rarely, and are used only to provide for the publication of information which does not naturally find a place in other channels. The usual number of scientific papers have been communicated by members of the staff to the various journals.

Grant from the Carnegie Institution.—The Carnegie Institution has appropriated $4,000 to be expended by the Director of the Yerkes Observatory for various investigations to be undertaken during the year 1903. These will include:—

1. A photographic investigation of stellar parallaxes, to be made by Dr. FRANK SCHLESINGER, now in charge of the International Latitude Observatory at Ukiah, California. Dr. SCHLESINGER will commence his work at the Yerkes Observatory in May.

2. Special photometric observations, by Mr. J. A. PARKHURST. Hitherto Mr. PARKHURST has devoted the greater part of his time to the measurement and reduction of stellar spectra, but hereafter his entire attention will be given to photometric work and related investigations on variable stars.

3. A detailed study of the photographs of the Sun, number-

ing over 3,000, taken during the years 1891-1896 with the spectroheliograph of the Kenwood Observatory. Mr. PHILIP FOX, formerly Instructor in Physics at Dartmouth College, is assisting in this work.

4. Various special investigations, which will probably include stellar and solar spectroscopic work with the cœlostat reflector. GEORGE E. HALE, *Director*.

LICK OBSERVATORY, MOUNT HAMILTON, CALIFORNIA.*

The Lick Observatory suffered an irreparable loss in the untimely death on August 12, 1900, of Dr. JAMES EDWARD KEELER, Director from June 1, 1898. The announcement of his death came as a great shock to his colleagues and friends widespread, who had seen before him a career of rarest promise. The elements of his successes were simple, and plainly in view. His openness and honesty of character, his willingness and quickness to see all points of view, his strong appreciation of the humorous as well as the serious, and, above all, his abounding good sense,—these traits made his companionship delightful and charming. His published papers have a completeness, a ripeness, and a finish rarely seen.

Our appreciation of his worth has not grown dim with time.

Dr. KEELER's last observations were made with the Crossley reflector in the hope of recording the image of a ninth satellite of *Saturn*, reported to exist by Professor W. H. PICKERING. No trace of the satellite was detected, but the plate of June 28, 1900, led to the discovery of an asteroid, *1900 GA*,—probably the faintest one known.

While the Observatory is pre-eminently an observation-station, yet it is not so in a narrow sense. Success in observational work demands, (1) knowledge of what has been done by others; (2) knowledge of pending problems, and of the most promising methods for their solution; (3) knowledge as to how observations will be used, and when they should be made, in order that they may bear most efficiently upon the problem.

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*Slightly abridged by Professor CAMPBELL from his "Biennial Report to the President of the University of California," covering the period July 1, 1900, to July 1, 1902.

An institution whose efforts were confined strictly to securing observations would soon be making inferior observations. Progressive observers must be acquainted with the theories of their subjects, and must undertake occasional theoretical studies, as well as computations of considerable extent. The Director has constantly held in mind the necessity for increasing the efficiency of the Observatory wherever possible. The instruments have been kept in perfect repair, and efforts have been made to provide all desirable improvements. Lack of financial resources has necessarily limited the latter work to the most pressing cases.

The hydraulic engine for turning the dome of the great telescope had been working badly for several years, limiting to an appreciable extent the productiveness of the telescope itself. The expert machinist who had superintended the erection of the dome was employed in January, 1901, to examine its running mechanism, and to make the necessary improvements. It was found that the brass feed-cylinders of the engine were badly worn, permitting very considerable leakage, thereby in effect decreasing the hydraulic pressure on the pistons. The cylinders were drilled true, and new piston-heads were provided. It is gratifying to report that the dome and its entire mechanism now perform at least as satisfactorily as they did when new.

The original design of the great telescope did not provide for power to wind the driving-clock; it was wound by hand. A Pelton water-wheel was installed for this purpose in 1890, but it never had sufficient power to do the work without assistance from the observer. In the past year the water-power has been applied more directly to the wheel, and the crude device for communicating the power to the clock has been replaced by sprocket wheels and chain. The winding apparatus now acts immediately, without assistance from the observer.

Further to increase its efficiency, Mr. WRIGHT has designed, and the instrument-maker has constructed, a device for turning the water-power on and off automatically. This will be put in place in the near future; and it is hoped that the observer's duties in connection with the clock will be confined to starting it in the evening and stopping it in the morning.

The need of a wind-screen in the opening of the dome had been felt for many years. The violent vibration of the telescope when the opening was turned toward the wind made it impossible to secure accurate observations. A temporary screen was put in place in the fall of 1900, especially for use in the *Eros* campaign. This served its purpose so well that a permanent screen on analogous lines was designed in 1901 by our carpenter, and was manufactured and put in place by him.

It is necessary that frequent repairs be made to the great telescope. This is not at all surprising in view of the fact that this excellent instrument is used throughout every good night. A serious defect recently developed in the Right Ascension slow-motion and clamping trains. This gradually grew more troublesome, until in April, 1902, these trains suddenly refused to operate. Upon investigation it was found that the trouble existed at the junction of the polar and declination axes. Unfortunately, the construction was such that the critical point was not accessible. Repairs called either for the dismounting of the telescope-tube, the declination-axis, and many minor pieces, or for the cutting of a hole through the cast-iron sleeve of the declination-axis. The latter method seemed preferable. My plans for this purpose were submitted to the makers of the telescope, the WARNER & SWASEY COMPANY, and met with their approval. When the hole was cut, it was found that the important cast-iron bearing block, where the trains turn through a right angle, had broken. This block was replaced by a larger steel one, constructed in our shops. For the first time in its history, I believe, the telescope was disabled for observational work. This was for two days only, while the new block was making. The value of our instrument-making shop was well illustrated on this occasion. Had it been necessary to secure machinists and tools from a distance to cut the hole in the telescope, and to have the broken parts constructed elsewhere, a delay of several weeks must have ensued, and the expense would have been correspondingly great.

The efficiency of the 36-inch equatorial was enormously increased a few years ago by illuminating the setting-circles by means of electric lights operated from the eye-end, according to Messrs. CAMPBELL and WRIGHT'S plans, thereby making it unnecessary for the observer to climb the high mounting, as he had theretofore done many times per night. Astronomer Hussey has recently equipped the twelve-inch equatorial (under his charge) in a similar manner, with good results.

Many minor improvements on the mounting of the Crossley reflector have contributed somewhat to its stability, but the necessity for providing this instrument with a new mounting has become more apparent with time to all who have used it. Director Keeler's remarkable success was achieved at enormous expense of time and physical energy. On the average, it was necessary for him to make four or five exposures on an object before a suitable negative was secured; and in many cases he had to be satisfied with enlarged and elongated star images. His experiences have been those of Assistant Astronomer Perrine, who is now in charge of the instrument. If the mirror were provided with a suitable mounting, observers possessing their great skill should have no difficulty in obtaining three successful negatives out of four attempts. The subject has been brought to the attention of the Lick Observatory Committee of the Regents, who have authorized the construction of a new mounting. Working drawings have been made by the firm of Harron, Rickard & McCone in accordance with general designs supplied by Mr. Perrine. Bids have been received from three responsible firms, and the contract is ready for letting. The smaller and more delicate parts of the mounting have been designed by Mr. Perrine, and these will be constructed in our instrument-making shops. It is hoped that the change from old to new may be made before the end of the year.

The original driving-clock of the Crossley reflector was replaced several years ago by a vastly more powerful one, from designs by Mr. Hussey. With the installation of the new mounting, only the 36¼-inch mirror of the original telescope will remain in use.

A generation ago the astronomer ordered his telescope and expected it to meet all his requirements. This is no longer sufficient. The wonderful developments of our science call for special instruments to do special work, and the so-called universal instrument is out of date. This is especially true in investigations along astrophysical lines. The successful instrument must have maximum efficiency in the problem to be solved. Every observatory of our class requires an instrument-making shop near at hand. This requirement is especially pressing here, on account of our unusual isolation.

The shops at the Lick Observatory were entirely inadequate for their purpose. The equipment consisted of two small, antiquated foot-power lathes, an antiquated hand-drill, files, etc.; and the carpenter's hand tools. The quantity of construction possible by their means was small, many vital parts of the instruments could not be made at all, vexatious delays in construction elsewhere were frequent, and our plans were rapidly falling in arrears to such an extent that the efficiency of the Observatory suffered severely. I therefore decided to utilize any available budget funds for the improvement of the machine-shops.

The carpenter-shop, paint-shop, and forge occupied adjoining rooms in a small brick building near the great dome, constructed by the Lick Trust. The paint-shop was removed to an isolated building beyond the barn, both to diminish risks from fire and to increase the space in the carpenter-shop. The inside walls of the forge-room were likewise removed. The resulting shop is twenty feet by twenty-six feet. An addition to this shop was built by the Observatory workmen in 1891, inside dimensions twenty-five by thirty-three feet, from brick left in the original Lick Trust kilns. This room had been used for storage, for the metal-working shop, and for a steam boiler and engine employed in charging storage batteries and in cutting the Observatory wood. The engine and wood-saw were removed to a small brick building, outside dimensions eleven by fourteen feet, built in 1901 to the east of the barn; and storage space has been found elsewhere. The rearranged room admirably meets the requirements of a complete instrument-making shop, on the desired scale. A Foos four-horse-power gasoline-engine was installed in the shop in place of the steam-engine. It drives all the metal- and wood-working machines described below. It is always ready to start, without waiting for steam to rise; the expense of fuel is small; it does not need the attention of a fireman; and it does not heat the work-room unduly. A Brown & Sharpe No. 1 Universal milling machine, a Brown & Sharpe tool-grinding machine, a modern wood-turning lathe, a wood rip-saw and an emery grinder were purchased in 1901. The old foot-lathes were modified to adapt them to power. The necessary shafting, pulleys, belting, attachments and small tools were likewise provided. The gasoline-engine drives the dynamo also.

The thoughtful generosity of Mrs. HEARST has enabled me to arrange for the completion of the shops without the delay that I feared might occur, by purchasing a modern lathe of fourteen-inch swing and eight-foot bed, with all necessary attachments; a power drill; a power saw for cutting metal; a cross-cut saw for wood; a wood-shaper; a small tempering and reducing furnace; and minor tools.

The schoolhouse, though small, is very complete and comfortable. The school is attended by nine children of various members of the staff. The teacher is supplied by Santa Clara County.

A tract of forty acres of land adjoining the reservation on the east, formerly belonging to JACOB WANDELL, was purchased by the University in 1901. Its location made control by the Observatory extremely desirable.

The principal buildings have for many years been painted a dull red color. This color was not in keeping with the character of the institution, nor was the quality of the paint adapted to the requirements of our climate. The smaller buildings and the residences were painted in various colors, and the effect was not at all pleasing. It was decided to have the outsides of all the buildings on the mountain painted on a uniform system, the roof to be tile-red, and the walls to be light yellow sandstone color, all to match the colors of the old California Mission buildings. The change was made last year for many of the smaller buildings, and the main building is now undergoing transformation. The general effect promises to be all that could be desired.

With the advice and assistance of the President, to meet a pressing want, the Lick Observatory early in 1901 began to publish the results of its observations in the Lick Observatory Bulletin. The earlier papers by members of the staff had appeared in various astronomical journals. While this plan relieved the University of expense and considerable labor, yet the vexatious delays sometimes occurring in the issue of important papers, and the appearance of the papers in so many mediums, were serious objections. The new plan has worked well, and the Bulletins are in great demand. They have been supplied gratis to other observatories, to academies of sciences, and to the principal investigators. Twenty-seven numbers have been issued up to date, and the distribution list includes about 430 addresses. The funds available for last year did not permit the insertion of many illustrations. The increased appropriation for the year 1902 will provide for a greater number.

The Observatory library is growing rapidly, so far as growth by exchange of publications is concerned, but there have been almost no funds available for purchases. Early volumes of several scientific periodicals, early volumes of observatory reports now obtainable only from second-hand dealers, and many standard books, both old and recent, are greatly needed. It is planned to supply a few of the most pressing of these needs in the near future from the funds provided by Mrs. HEARST. The library contains about 5,000 volumes and 4,800 pamphlets. It has outgrown the capacity of the library-room. Suitable hardwood book-cases have been constructed in the main corridor for the overflow. In this way the space requirements will probably be met for many years. The library is in charge of Assistant Astronomer AITKEN.

Up to the beginning of the year 1901 it had been the practice of the directors of the Observatory to write all the letters personally. The correspondence has always been heavy, and the tax upon valuable time and physical strength for this purely mechanical labor has been very great. It seemed to me that modern methods should be adopted. The former Secretary's time had through experience become too valuable scientifically to justify his retention in that office. It was arranged that his services should be available entirely for investigational work, and a secretary who was also a stenographer was employed in his stead.

The arrangements inaugurated by Director KEELER regarding fellowships in the Lick Observatory have been very satisfactory. The immediate output of scientific results would be considerably greater if the funds, originally paid to an astronomer and now paid to the Fellows, could be used in the employment of regular assistants who would spend all their time on the mountain. But the training of the astronomers of the future is so manifestly one of the duties of the University that the arrangement should be continued.

The greater part of the time of the Fellows during their first two years of residence is devoted to assisting the astronomers in the more routine parts of their work; but with the acquirement of experience and skill, greater responsibilities are placed upon them, and the assignment of original investigations to them is planned in all cases.

It is a great pleasure to record the following generous gifts to the Lick Observatory:—

In December, 1900, D. O. MILLS, Esq., provided a fund of $24,000, plus ten per cent. for unexpected expenses, for a spectroscopic expedition to the southern hemisphere. This gift is noted more fully below.

WILLIAM H. CROCKER, Esq., provided a fund of $3,000 to defray the expenses of an expedition to Sumatra to observe the total solar eclipse of May 18, 1901. The work of the expedition is described in detail in other paragraphs.

A grant of $500 from the Draper Fund of the National Academy of Sciences was made in February, 1901, for the purpose of constructing a modern one-prism spectrograph. The designing of this instrument was delayed until the completion of the reflecting telescope for the southern hemisphere.

Mr. D. O. MILLS has presented the sum of $1,000 for the reconstruction of the original Mills spectrograph. It was built in the age of brass; the new instrument will be of steel in all its vital parts. It will also contain many important modifications resulting from our six years' experience with the original instrument. The reconstruction is now under way.

Mrs. PHŒBE A. HEARST has thoughtfully provided the sum of $2,500, available during the year 1902, to be expended for equipment purposes. As a result of her generous gift, several departments of the Observatory will be equipped for more efficient work.

The total value of these gifts in the past year and a half is $33,400.

The Wells, Fargo Express Company, on several occasions, granted half-rates on heavy and valuable shipments. In recognition of our time signals, the Southern Pacific Company has given reduced rates for passage and freight in connection with eclipse expeditions, shipment of heavy goods, etc. The Toyo Kisen Kaisha, the Occidental and Oriental Steamship Company, the Pacific Mail Steamship Company, and the Dutch East India steamship companies granted concessions to the Sumatra Eclipse observers. Prominent firms in San Francisco and in the East have in every case supplied tools for our instrument-shops at rates lower than commercial firms must pay. The total value of the concessions cited above approximates $1,800 for the past two years. The power of our resources to produce useful results was increased to that extent, and the thanks of the Observatory are due to the companies mentioned.

It was Director KEELER's purpose to secure with the Crossley Reflector satisfactory photographs of about one hundred of the principal nebulæ and star-clusters. The portions of his programme available for observation in our clear summer weather were practically complete at the time of his death, but those in position during the cloudy winter months were incomplete. We have made it a duty to carry on Director KEELER's work as rapidly as possible, but the necessity for securing observations of the planet *Eros* and of the eclipse in Sumatra has interfered to some extent. The amount of clear weather in the past winter and spring has likewise been very much less than the average, and gaps in this part of his programme still remain. As soon as satisfactory negatives of all the objects have been obtained, the results should be published in the best possible manner. The making of plates for reproducing the photographs will be a very painstaking and expensive process, but it is hoped that funds may be obtained from private sources to an amount sufficient to do justice to Dr. KEELER's work and memory.

Through the continued generosity of Mr. WILLIAM H. CROCKER, a well-equipped expedition, in charge of Acting Astronomer PERRINE, accompanied by Assistant RALPH H. CURTISS, sailed from San Francisco in February, 1901, to observe the total solar eclipse of May 18th, on the west coast of Sumatra. The affairs of the expedition, personal, financial, and scientific, were admirably managed by Mr. PERRINE. The ten instruments were duly mounted and placed in perfect adjustment. Fifteen volunteer assistants, Dutch residents in Sumatra, were trained to their duties, and the entire programme of photographic exposures outlined for the expedition went through without a hitch. All went well, save that the eclipsed Sun was obscured at the beginning of totality by thin clouds, which gradually thickened during the 6½ minutes of the eclipse.

To the surprise of the observers, when the negatives were developed it was found that the observations were extremely satisfactory, valuable results having been secured with all of the ten instruments. The instruments and photographs were delayed in transit homeward, and did not reach Mt. Hamilton until October. Examination of the plates more than confirmed Mr. PERRINE'S report. A study of the photographs has shown that, in spite of the thin clouds, the expedition was at least as successful as any eclipse expedition ever sent out by any institution.

The general results have been published in a preliminary manner in Lick Observatory Bulletin No. 9, but attention should be called to a few of the more important ones:—

The photographs obtained with the forty-foot camera are admirable, the general features of the inner and middle corona being shown as well as if there had been no clouds. A most interesting and unique coronal disturbance was recorded in position-angle 60°. A comparison of the solar photographs with those made on the days preceding and following the date of the eclipse by English observers in India led to the very important conclusion that the coronal disturbance was situated immediately above the prominent and only sun-spot group visible on those days.

The spectrographic and polarographic results were completely successful, perhaps more so than would have resulted from an unobscured eclipse. They established that the spectrum of the outer corona is identical with that of ordinary sunlight, and therefore that the light of the outer corona is not inherent, but is reflected light originating in the main body of the Sun; that the spectrum of the inner corona is continuous, and therefore is not reflected sunlight, but is inherent; that the outer corona shows the strong polarization effects that would be expected to result from its character as reflected light; and that the inner corona gives only slight evidence of polarization, as would be expected from light largely of an inherent character.

Mr. PERRINE has carefully examined the plates secured with four cameras for the purpose of detecting any possible intra-Mercurial planets. The instruments gave splendid definition, and in the unobscured areas surrounding the Sun stars down to the ninth magnitude were recorded. The search was highly satisfactory for more than two thirds of the area under examination, but the clouds prevented complete success in the remaining one third. No unexpected objects were detected. While the discovery of unknown objects as a result of this search would have been more interesting, yet negative and positive results would possess equal value scientifically.

The expedition received very extensive help from the Dutch Government in Sumatra, from the lines of steamers patronized, and from individuals at all transfer points.

Mr. CROCKER's services to eclipse astronomy have been highly appreciated by astronomers and other men of science throughout the world.

The discovery of the minor planet *Eros* in 1898, and the recognition of the unusual opportunities offered by it for an improvement in our knowledge of the distance of the Sun, led to the organization of a coöperative scheme on the part of forty or fifty leading observatories, to secure the necessary observations in the fall of 1900. The Lick Observatory entered energetically upon the programme outlined. Astronomer TUCKER secured more than two thousand meridian-circle observations of the 678 reference stars, required as a basis for the entire problem. The microscopes were read by Dr. R. T. CRAWFORD for about 1,600 of the observations, and he rendered some assistance in the computations, but Mr. TUCKER was unassisted in the bulk of the reductions. The results were published in Bulletins Nos. 1 and 2, in February and May, 1901, respectively. The prompt completion and publication of this extensive piece of work, long in advance of the appearance of results from the other observatories, called forth many expressions of surprise and admiration for the energy and skill of the astronomer in charge.

Careful micrometer measures of the position of *Eros* were obtained by Astronomer HUSSEY and Assistant Astronomer

AITKEN, with the thirty-six-inch equatorial. The former made 832 measures in Right Ascension, and 896 in Declination; the latter 1,650 in Right Ascension and 729 in Declination. Photographic observations were secured in great numbers with the Crossley reflector by Assistant Astronomer PERRINE, assisted by Fellow H. K. PALMER. They include 344 plates on sixty-three nights for accurate meridian places of the planet; 511 plates on thirty-seven nights for a parallax; 110 charting and connecting plates; total, 965 plates, of which 854 contain short exposures for measurement, carrying over four thousand images of the asteroid. The micrometer results, and a list of the photographic plates, are published in Bulletin No. 13. The measurement and reduction of these plates will be an enormous task. Fortunately, Professor REES, Director of Columbia College Observatory, has agreed to undertake that work. His efficient bureau of measurement and reduction, in immediate charge of Professor JACOBY, has already measured and reduced a number of the plates.

Perhaps the most interesting astronomical events of recent years relate to the new star in *Perseus*, discovered in Edinburgh on February 22, 1901. The Lick Observatory, in common with all similar institutions, made immediate plans to bring every available resource to bear upon the study of this star. Its position was measured by Mr. TUCKER with the meridian-circle, and by Mr. AITKEN with the thirty-six-inch equatorial on several occasions in the spring and summer of 1901. It is clear from their observations, amply confirmed by those made elsewhere, that the new star is at least as far away as the faint stars surrounding it, and that its motion with reference to the surrounding stars is so slight as to elude detection for the present. Our two spectroscopes suitable for the study of the new star were sent to Sumatra with the Eclipse Expedition only two or three days before the announcement of the discovery reached us. Fortunately, the Observatory possessed a good collection of lenses and prisms; and from these, spectroscopes were mounted very promptly in our instrument-making shops, so that practically no time was lost on that account. The spectroscopic observations by Messrs. CAMPBELL and WRIGHT, assisted by Dr. REESE, were extremely fruitful in results. They have been published in Bulletin No. 8.

Spectrum photographs were secured by Fellow JOEL STEBBINS with the Crossley reflector, which led to the discovery of two new bright lines in the ultra-violet portion of the spectrum. The brightness of the star was observed on all possible occasions, during its period of rapid fluctuation, by Messrs. AITKEN and STEBBINS. It was the brightest star in the northern sky on February 24th; it has now declined to the ninth magnitude, having been in the mean time converted into a nebula.

A photograph by WOLF, of Heidelberg, on August 23, 1901, had led to the discovery of masses of nebulosity in the vicinity of the new star. A photograph by RITCHEY, of the Yerkes Observatory, on September 20th, confirmed and extended the discovery, showing that the new star was apparently situated in a nebulous mass nearly circular in form, and of great extent. The photograph of this region made by Mr. PERRINE with the Crossley reflector, on November 7th and 8th, led to the extraordinary discovery that the well-defined nuclei in the nebula were apparently in rapid motion; the magnitude of the apparent motion being at least seventy-five times as great as any sidereal motion previously known. Telegraphic announcement of this discovery was made at once, and intense interest was taken in the subject. A photograph made by RITCHEY at the Yerkes Observatory, on November 9th, afforded full and independent confirmation of Mr. PERRINE'S remarkable discovery. Photographs made at intervals throughout the winter have enabled us to follow the motions of the brighter masses.

Following this discovery, there were frequent expressions of regret that no record of the nebulosity had been obtained between the discovery of the star in February and the epoch of WOLF'S photograph. Numerous short-exposure plates of the new star had been obtained by Messrs. PALMER and DALL with the Crossley reflector early in the year. Examination of these by Mr. PERRINE in January, 1902, led to the happy discovery that two rings of nebulosity surrounding the new star were beautifully recorded on Mr. PALMER'S plate of March 29th. We were thus able to extend the history of the phenomenon backward five months.

The nature of the phenomenon is a mooted question. The favorite theory is that invisible masses of nebulosity existed in this region previous to the formation of the new star; and that the great wave of light, sent out when the brightness of the star was at a maximum, was sufficient to illuminate the dark masses and make them visible to us by reflected light. Bearing upon this question, Mr. PERRINE secured valuable polariscopic evidence. A photograph of the nebula was obtained after passing the light through a double-image prism, placed at a short distance in front of the plate-holder in the Crossley reflector. Two images of each of the principal nuclei were recorded in such a way as to make it certain that the polarization effects to be expected from reflected light are entirely absent. It is hoped that a complete series of observations of this interesting object may be obtained during the coming autumn, and that the principal masses will be bright enough to permit a study of their spectra by means of a small spectrograph that Mr. PERRINE has planned.

The consensus of opinion is that the new star is the result of a violent collision between two dark stars, or between a dark star and a nebula. It can easily be shown that the kinetic energy of two such bodies, approaching and colliding with enormous relative speed, would be converted into heat in sufficient quantities to transform the dark bodies into incandescent gases. The history of previous new stars had led us to expect that the spectrum would gradually change into that of a nebula, and in this we were not disappointed. For a suitable study of the present nebular spectrum of the new star it was necessary that further and more accurate investigations be made upon the spectra of the well-known nebulæ. These investigations were undertaken with great success by Assistant Astronomer WRIGHT. His results have been published in Bulletin No. 19. Not only did he determine the positions of many well-known nebular lines more accurately than had previously been done, but a number of very interesting new lines were detected.

Very little attention has been given to the subject of comet-seeking, on account of pressure of work in other lines, although search has been made by Mr. PERRINE for a few periodic comets whose returns were expected. These include the Di Vico-Swift comet, BARNARD's comet of 1884, and SWIFT's comet of 1895. No trace of these was discovered, no doubt on account of their faintness, or of their defective orbits.

Micrometer observations of comets in the past two years have been secured, as follows:—

Comet *a* 1900,	AITKEN, 3 nights,	PERRINE, 4 nights.
" *b* 1900,	" 10 "	" 3 "
" *c* 1900,	" 6 "	
" *a* 1901,	" 2 "	
" *a* 1902,	" 2 "	

The measures of Comet *a* 1901 and of Comet *a* 1902 were the only ones made in the United States. Valuable photographs of Comet *a* 1901 were secured by Mr. PERRINE at the Eclipse Station in Sumatra. An orbit of Comet *b* 1900 was computed by Mr. PERRINE, and of Comet *c* 1900 by Mr. AITKEN. Some very interesting photographs of Comet *b* 1900 were secured by Mr. PALMER.

Extensive series of measures of satellites of planets were obtained by various members of the staff, observations being limited in all cases to those most desired by investigators of their orbits.

Two hundred and fifteen observations of the relative positions of the satellites of *Saturn* were made by Mr. HUSSEY with the thirty-six-inch equatorial.

Mr. AITKEN made the following observations with the thirty-six-inch equatorial:—

Satellites of *Uranus*,	27 nights.
" " *Neptune*,	13 "
" " *Mars*,	7 "
Fifth satellite of *Jupiter*,	2 "

At the request of Professor NEWCOMB, Mr. PERRINE photographed the planet *Neptune* and its satellite on thirty plates, in January, 1902, with the Crossley reflector. The measurements of these plates furnish fifty-one determinations of the position of the satellite, with reference to its primary. Photographic methods have been but little used in this line of work, and it is interesting to note that the smallness of the errors of observation justifies the application of the method in all possible cases.

The work with the meridian-circle has been most efficiently prosecuted. Since July 1, 1900, Mr. TUCKER has obtained 6,500 complete observations. These include observations of *Eros* comparison-stars; of *Eros* itself; of *Nova Persei;* and of zodiacal stars, greatly needed at the present time, to be used as a basis for improving the orbits of the major planets.

The manuscript for *Lick Observatory Publications*, Volume VI, is entirely ready for the printer. The volume will contain results of meridian-circle work from July, 1896, to March, 1901, and will include about 14,000 complete observations of 4,500 stars. The labor entailed in securing, reducing, and preparing these observations for publication has been very great. Mr. Tucker has had assistance from Messrs. Crawford, Dall, Curtiss, and Palmer, amounting to about six months full time of one computer during the past two years. The remainder of the work has been carried on without assistance.

Fellow R. T. Crawford assisted in meridian-circle work during the years 1898-1901. At the end of his service he received the degree of Doctor of Philosophy, having taken for his thesis the subject of "The Refraction-Constant at Mt. Hamilton."

The department of astronomy known as Double Stars has been most ably advanced by Messrs. Hussey and Aitken. The former has devoted perhaps three fourths of his time and the latter one half his time to this line of investigation. Their programmes have been admirably developed and systematized, and results of prime importance have been surprisingly numerous. It is not too much to say that their discoveries and observations of new double stars, and their measures of known double stars, outnumber several-fold the corresponding output of all other observatories in the past two years. An equally satisfactory statement can be ventured as to the accuracy attained. Both observers have devoted a portion of their time to the discovery of new pairs. Mr. Hussey has found 312 systems in the past two years, and 564 since 1898. They may be classified as follows:—

Distances between 0″.00 and 0″.25,	41 pairs.
0 .26 " 0 .50,	103 "
0 .51 " 1 .00,	123 "
1 .01 " 2 .00,	128 "
2 .01 " 5 .00,	168 "
Over 5 .00,	1 "
Total	**564 pairs.**

It will be seen that 47 per cent of his discoveries have distances less than 1″, and 70 per cent less than 2″.

The corresponding discoveries by Mr. Aitken have been 249 since July, 1900, and 345 since 1898, as follows:—

Distances between 0″.00	and	0″.25,	20 pairs.
0 .26	"	0 .50	55 "
0 .51	"	1 .00,	78 "
1 .01	"	2 .00,	91 "
2 .01	"	5 .25,	101 "
		Total	345 pairs.

Forty-five per cent of these are under 1″, and 71 per cent under 2″.

By way of explanation, it should be said that in general the closer the components of a pair the more interesting and important it is. The majority of stars in which orbital motions have been detected are closer than 1″. Up to the present time about 1,500 double stars with distances under 1″ have been discovered at all the observatories. More than one third of these have been found at the Lick Observatory, and more than one fourth of the whole number have been discovered here within the last three years.

Many interesting results have come from the systematic observation of the well-known interesting pairs. Of these, the most striking case is δ *Equulei*. It was supposed that its period of revolution was 11.4 years,—surpassed in rapidity of motion only by κ *Pegasi*, period 11⅓ years. In the fall of 1900 it was noticed by Mr. Aitken that the components of δ *Equulei* were not following the paths marked out for them by the orbit hitherto accepted as substantially final. Mr. Hussey investigated the question of their orbit, making use of all the known observations. He came to the conclusion that the chances were greatly in favor of a period only one-half the length of that previously assumed, namely, 5.7 years. Systematic observations by Messrs. Hussey and Aitken during the past year have established the correctness of this view. The period of this interesting binary is fifty per cent shorter than that of any other known double star. Observations of this system obtained with the Mills spectrograph are in harmony with Mr. Hussey's theory.

Mr. HUSSEY has also in the past two years secured

881	micrometrical	observations	of newly discovered pairs.
801	"	"	" W. Struve pairs.
54	"	"	" Otto Struve pairs.
63	"	"	" miscellaneous pairs.
Total, 1,899			

Mr. AITKEN has obtained 1,431 observations, his observing-list being mainly composed of known rapid binaries, and other close and difficult pairs. He has likewise computed orbits for 99 *Herculis*, *ζ Sagittarii*, and *β Delphini*.

Mr. HUSSEY completed his observations and discussions of the Otto Struve double stars, and his work was issued in the summer of 1901 as Volume V, *Publications of the Lick Observatory.* This volume is of great utility to double-star observers. It met with an excellent reception from his fellow-workers.

In the year 1900, the Lick Observatory agreed to coöperate with the Harvard College, Yerkes, and University of Virginia observatories, in observing photometrically ten stars in the immediate vicinity of each of thirty-six well-known variable stars, under the auspices of the Rumford Committee of the American Academy of Arts and Sciences. The photometer was designed and supplied by Professor PICKERING, Chairman of the Committee; but, on account of the greater brightness of the images formed by the thirty-six-inch telescope, it was necessary to change its form before beginning observations. The work on *Eros,* the solar eclipse, and the new star, combined with the smallness of our staff, delayed work on the programme until June of this year. Results are now rapidly being obtained by Mr. AITKEN and Dr. S. D. TOWNLEY, of the Berkeley Astronomical Department, who spent his summer vacation here in several phases of photometric work.

The Crossley reflector has been busy on practically every good night. In addition to the observations already referred to, Messrs. PALMER and DALL made thirty-three exposures on the nebulæ contained in Professor KEELER's programme, in the first half of 1901. Mr. PERRINE has since secured twenty-three exposures on these nebulæ, twenty-eight exposures on the Rumford variable star regions referred to above, and twenty-five exposures for miscellaneous purposes. Fellows

PALMER, STEBBINS, and CURTISS have ably assisted in the observations with the Crossley reflector.

A small slitless spectrograph was designed by Professor KEELER for use on faint objects with the Crossley reflector. It was completed on the day of his departure from the mountain. It was tested promptly by Messrs. CAMPBELL and PALMER, who found it necessary to use convex and concave quartz lenses in connection with the quartz prism, in order that the rays should be parallel when passing through the quartz prism. These changes were designed by Mr. PALMER, and the instrument was used extensively by him. He secured seventy spectrograms of the smaller planetary nebulæ and of other small objects. Many interesting facts resulted from these observations. I shall refer only to his success in photographing extremely faint spectra. A strong image of the spectrum of *Nova Cygni*, visual magnitude about 15.5, was obtained with ease. Successful exposures could probably be made on stars at least a magnitude fainter. His photograph of *Nova Cygni* demonstrates that the spectrum, which was nebular in 1877, has now become continuous, like that of the ordinary stars.

In addition to the observations of *Eros*, positions of asteroids *1900 GA*, *Ohio*, and *Palatia*, were determined by Mr. PALMER, from photographs taken with the Crossley reflector. Mr. HUSSEY secured eight observations of the asteroids *Minerva*, *Edna*, (440), and *Chicago*. Messrs. PALMER and CURTISS have recently secured photographs of several asteroids whose positions were requested, and the plates are being measured by Mr. CURTISS.

Mr. PERRINE has made 200 copies on glass of the eclipse photographs secured in India in 1898, in Georgia in 1900, and in Sumatra in 1901, for distribution to institutions, to societies, and to individual investigators taking special interest in this subject.

Three nights per week with the 36-inch equatorial have been devoted to the determination of the motions of the brighter stars in the line of sight, with the Mills spectrograph, during the past six years. The importance of line-of-sight investigations is attested by the fact that nearly all the powerful telescopes in the world are devoted at present largely to this purpose, though with varying degrees of success. The accuracy of the Lick Observatory determinations has steadily progressed until, for the stars containing fine lines, the probable error of a single determination of velocity is only about 0.25 kilometer.

To the list of fifteen spectroscopic binaries discovered prior to Director KEELER's report of July 1, 1900, I desire to make twenty-three additions, as follows:—

β *Herculis,*
ξ *Ursæ Majoris,*
δ *Bootis,*
113 *Herculis,*
η *Andromedæ,*
π *Cephei,*
ξ *Piscium,*
ξ' *Ceti,*
δ *Equulei,*
ζ *Herculis,*
o *Andromedæ,*
γ *Canis Minoris,*
12 *Persei,*
93 *Leonis,*
β *Scuti,*
2 *Scuti,*
κ *Pegasi,*
31 *Cygni,*
τ *Persei,*
ε *Hydræ,*
α *Equulei,*
φ *Persei,*
η *Geminorum.*

These thirty-eight systems have been discovered since 1898. The satisfactory character of the results obtained with the Mills spectrograph, both in quantity and in quality, may be inferred from the fact that during the time these thirty-eight spectrographic binary systems were coming to light as a result of our work, only eight similar systems were announced by other observatories, and three of the eight were erroneous.

There is room for reference to only two of the stars on the above list: ζ *Herculis* is a short-period visual binary star, completing a revolution in about thirty-three years. The velocity of the principal star in the line of sight is slowly varying. κ *Pegasi* is one of the most interesting visual binaries known, period 11⅓ years. Until the discovery of the true period of δ *Equulei,* this was supposed to be the shortest period known. One of the components of κ *Pegasi* is a spectroscopic binary, having a period of only six days.

These binary systems have been discovered in the process of determining the velocities of about 350 stars; in this list of 350, previous observers had discovered three binaries. Without taking into account a list of several suspected binaries, it is apparent that of the brighter stars at least one in every seven or eight is attended by an invisible companion. When we consider that spectroscopic methods are at present capable of discovering only the larger variations, that very few stars of long periods have probably been advantageously observed as yet, and that the velocity of our Sun, due to the orbital motions of the planets attending it, has a double amplitude of only two or three hundredths of a mile per second, there can be no doubt that the number of spectroscopic binaries must be very great. It is probable that the star unattended by dark companions will be found to be the exception rather than the rule.

Mr. WRIGHT has computed the orbit of the spectroscopic binary χ *Draconis*. Dr. REESE has computed the orbit of the spectroscopic binary *Capella*. Director CAMPBELL has computed the orbit of the variable star and spectroscopic binary ζ *Geminorum*. Dr. CRAWFORD has computed the orbit of the spectroscopic binary η *Pegasi*.

Dr. REESE, at my request, investigated the question of the diffraction of light of variable intensity, with special reference to the Mills spectrograph, as a guide in designing a more powerful instrument. He has likewise investigated the cause of the discrepancies between measures of spectrograms made with the violet end to the left, and with the violet end to the right, as a result of which he established the purely physiological cause of the discrepancy.

Dr. REESE has also designed the new mounting for the Mills spectrograph, referred to in a previous paragraph.

Photographs and preliminary measures of several hundred spectra have been made by Messrs. CAMPBELL, WRIGHT, and REESE; and a considerable number of definitive measures have been made.

In December, 1900, the Director utilized the results obtained for the velocities of 280 stars situated north of —20° Declination in determining the speed and direction of the motion of the solar system through space. The result for the speed of the solar system comes out 19.9 kilometers, or 12.4 miles per second. The apex of the motion is in R.A. 277° 30′, Declination +20°. The result for speed is very satisfactory. On account of the absence of material from the southern hemisphere, and the consequent irregular distribution of the observed stars over the sky, the direction assigned must be regarded as a rough approximation.

The average velocity in space of the 280 stars is 34.1 kilometers per second. The velocity of the solar system is therefore much less than the average for the other stars.

Another result of great interest is to the effect that the fainter stars are moving much more rapidly than the brighter ones.

The velocities of the stars have been observed to bear all values between sixty miles approach and sixty miles recession per second.

Investigations in this line have been shown to be practically endless, by our measurements of the velocity of the star *Groombridge 1830*. A special effort was made to measure its velocity, as this is the star which up to three years ago had the largest known proper motion. Its photographic magnitude is in the neighborhood of 7.5. The results obtained have shown that the observations may be extended by present methods to stars perhaps a magnitude fainter. Stars available for measurement are therefore numbered by thousands. As soon as half a dozen of the eight or ten great telescopes now engaged in this work have been made to produce accurate results, it will be highly desirable that the interested observatories arrange and carry out a scheme of coöperation on a large scale.

From Mt. Hamilton it is possible to secure the speeds of the stars between the North Pole and 30° South Declination. The stars in the quarter of the sky from 30° South to the South Pole remain unobserved. For many years it has been my desire to organize an expedition to the southern hemisphere for the purpose of measuring the velocity of these stars. The time for organizing this expedition seemed to have come in the winter of 1900. With the approval and indorsement of the President, the subject was brought to the attention of Mr. D. O. MILLS, who most generously offered to provide funds for constructing the instruments, for defraying traveling expenses, and for paying the salaries of the astronomers engaging in the work. It was decided to construct a reflecting telescope mounting to carry the extra 36¼-inch mirror that was in our possession, first cutting a hole through the center of the mirror in order that the Cassegrain form of mounting could be utilized. It was known that the mirror was of imperfect figure, and it was planned to have the JOHN A. BRASHEAR COMPANY refigure it after the hole had been cut. Unfortunately, in the process of cutting, the mirror broke in pieces on account of its enormous internal strains. This was not a misfortune, as Dr.

BRASHEAR reported that, on account of its very imperfect annealing, this piece of glass could never have been made to work well. A new mirror was ordered at once.

The telescope mounting, designed in general features by the Director, was brought to the mountain in December, 1901.

A powerful three-prism spectrograph, designed by the Director for use with the reflecting telescope, is completed. The delicate parts of the mounting were constructed by our instrument-maker, and the optical parts by the JOHN A. BRASHEAR COMPANY. Mr. WRIGHT has submitted the whole spectrograph to severe tests. Its performance appears to be superior even to that of the original Mills spectrograph. A modern steel dome was built for the expedition by the WARNER & SWASEY COMPANY, and was shipped to San Francisco on June 21st. The minor pieces of apparatus required have all been provided. It is planned to select a suitable observing-station in the vicinity of Santiago, Chile. It is confidently hoped that this work will be at least as fruitful as that carried on with the Mills spectrograph attached to the thirty-six-inch equatorial.

The Director wishes to make full acknowledgment of the enthusiastic support afforded him by the members of the Observatory staff. Every man has been ready to make the most of the opportunities supplied by the splendid instruments, by the unexcelled climatic conditions, and by the excellent policy inaugurated for the Observatory by the officers of the University of California.

W. W. CAMPBELL, *Director*.

GENERAL NOTES.

Astronomy in the Carnegie Institution.—In *Science* for January 30th, President Daniel C. Gilman, of the Carnegie Institution, publishes a detailed account of the proceedings of the Institution during the first year of its existence. From this account we extract such information as is of especial interest to astronomers.

In order to determine what work should be entered upon by the Institution, an advisory committee was appointed in each of eighteen sciences; that for astronomy is made up of E. C. Pickering (Harvard), Lewis Boss (Albany), George E. Hale (Yerkes Observatory), S. P. Langley (Smithsonian Institution), and Simon Newcomb. Some other names well known in astronomy are to be found among the other committees: Ormond Stone *(Mathematics)*, R. S. Woodward, and A. A. Michelson *(Physics)*, T. C. Chamberlin *(Geology)* and Cleveland Abbe *(Meteorology)*.

At its meeting in November, 1902, the Board of Trustees made the following appropriations for research, aggregating $185,200:—

Astronomy	$21,000
Bibliography	15,000
Botany	11,700
Chemistry	3,000
Economics	15,000
Engineering	4,500
Exploration	5,000
Geology	12,000
Geophysics	8,500
History	5,000
Investigation of project for southern and solar observatory	5,000
Investigation of project for physical and geophysical laboratories	5,000
Investigation of natural history projects	5,000
Marine biological research	12,500
Paleontology	1,900
Physics	4,000
Physiology	5,000
Psychology	1,600
Publications	5,500
Research assistants	25,000
Student research work in Washington	10,000
Zoölogy	4,000

It will be seen that the appropriation for astronomy is considerably in excess of that for any other science, even without the $5,000 allotted to an investigation of the project for a southern observatory. The reason for this will be found in the avowed objects of the Institution, to favor those projects which seem to require immediate assistance, and to avoid coming into competition with other agencies for the promotion of research.

Some of the grants in astronomy are as follows: $2,500 to Harvard Observatory, to assist in a more thorough study of the astronomical photographs that are being made at Cambridge and at Arequipa; $4,000 to the Yerkes Observatory, for an investigation of stellar parallaxes by means of photography, investigations in stellar photometry, a study of several hundred photographs of the Sun taken at Kenwood Observatory in the years 1891 to 1896, and for certain other investigations in solar and stellar spectroscopy; $4,000 to the Lick Observatory, to be expended in the employment of assistants and computers; $1,000 to Vassar College Observatory, to make measurements and reductions of photographs of stars in the region of the north pole of the heavens. We regret that we cannot give a complete list of the separate grants in astronomy. The secretary of the Institution informs us that the trustees have decided to leave the announcement of grants to such of the grantees who may desire to make them.

Recent Meetings of Astronomical Societies.—This country now has two societies of professional astronomers: the Astronomical and Astrophysical Society of America, and Section A (*Mathematics* and *Astronomy*) of the American Association for the Advancement of Science. These societies are in no sense rivals, especially since the affiliation of the former with the American Association. The two now hold meetings at the same time in the same city, and the privileges of the meetings of each are extended to the members of the other. The meetings for this year were held at Washington during "convocation week," beginning Monday, December 29, 1902.

The Astronomical and Astrophysical Society elected the following set of officers for 1903:—

President—SIMON NEWCOMB.
First Vice-President—GEORGE E. HALE.
Second Vice-President—W. W. CAMPBELL.

Treasurer—C. L. Doolittle.

Councilors—Ormond Stone, W. S. Eichelberger.

Secretary—George C. Comstock.

Besides Professor Newcomb's address on "The Universe as an Organism," the following papers were read:—

H. Jacoby: Photographic Measures made with the *réseau* and without.

George E. Hale, Ferdinand Ellerman, and J. A. Parkhurst: The Spectra of Stars of Secchi's Fourth Type.

W. J. Humphreys: Certain Matters Connected with Spectroscopic Methods.

E. B. Frost and W. S. Adams: (1) Radial Velocities of Twenty Stars having Spectra of the *Orion* Type. (2) New Spectroscopic Binaries. (3) The Wave-lengths of Rydberg's First Line of Hydrogen (λ 4686) and Others.

W. S. Adams: The Orbit of the Spectroscopic Binary η *Orionis.*

E. O. Lovett: (1) Periodic Solutions of the Problem of Four Bodies. (2) On the Integrals of the Problem of n Bodies.

G. C. Comstock: The Masses in 85 *Pegasi.*

F. W. Very: Form and Structure of the Galaxy.

S. A. Mitchell: Neon, Krypton, and Zenon in the Chromosphere.

G. C. Comstock: Proper Motions of Faint Stars.

Sarah F. Whiting: Astronomical Laboratory Work.

F. W. Very: Cause of the Nebulosity Around *Nova Persei.*

G. W. Hough: The Mounting of Fixed Meridian Instruments.

J. A. Parkhurst: Faint Variable Stars.

S. C. Chandler: The Value of the Aberration Constant.

C. L. Doolittle: Constant of Aberration from Observations in 1901-1902.

E. F. Nichols and G. T. Hull: The Pressure of Light.

E. E. Barnard: (1) Triangulation of Stars in Four Globular Clusters. (2) Observations of Variable Stars in Globular Clusters.

A. O. Leuschner: (1) Short Method of Determining Orbits. (2) A Method of Computing Orbits in Rectangular Coördinates. (3) The Solution of the Orbit Irrespective of Parallax and Aberration. (4) The Orbit of Comet 1902 a.

G. H. PETERS: The Photoheliograph of the Naval Observatory.

SIMON NEWCOMB: Statement of the Progress made by the Watson Trustees in Computing Tables of the Watson Asteroids.

A. S. FLINT: Meridian Observations for Stellar Parallax.

L. A. BAUER: Magnetic Results during the Eruption in Martinique.

S. D. TOWNLEY: The Light of the Stars.

Abstracts of most of these papers may be found in *Science* for February 27, 1903; and President NEWCOMB's address is printed in full in *Science* for January 23, 1903.

Section A of the American Association elected OTTO H. TITTMANN as Vice-President for the next meeting and L. G. WELD as Secretary. An address "On the Physical Constitution of the Planet *Jupiter*" was delivered by Professor G. W. HOUGH, and is printed in *Science* for January 16, 1903; in the same place may be found abstracts of the papers read before the meetings, the titles of which follow:—

O. H. TITTMANN: Deflections of the Vertical in Porto Rico.

L. G. WELD: SAINT LOUP's Linkage.

S. P. LANGLEY: A Device to Prevent Personal Equation.

S. P. LANGLEY: The Solar Constant and Related Problems.

S. P. LANGLEY: Good Seeing.

PAUL CARUS: The Foundations of Mathematics.

F. H. BIGELOW: Structure in the Mass of the Sun.

P. LOWELL: Spectroscopic Proof of the Rotations of *Jupiter, Saturn,* and *Venus.*

G. B. HALSTED: The Teaching of Geometry.

E. O. LOVETT: Special Periodic Solutions of the Problem of *n* Bodies.

E. O. LOVETT: The Problems of Three or More Bodies with Prescribed Orbits.

ASAPH HALL: Secular Perturbations of the Planets.

G. B. HALSTED: The BOLYAI Centenary.

C. J. LING: Approach of Comet *b* 1902 to *Mercury.*

G. A. HILL: An Untried Method of Determining the Constant of Refraction.

J. T. QUINN: Development of Conic Sections by Kinematic Methods.

G. C. COMSTOCK: Time Determinations at Washburn Observatory.

C. S. HOWE: Determination of Time by Reversing on Each Star.

JAMES S. MILLER: Geometrical Analysis.

C. J. KEYSER: BOLZANO'S Contributions to Assemblage Theory.

C. W. FREDERICK: The Constants of the Equatorial.

LUIGI D' AURIA: A Relation between the Mean Speed of Stellar Motion and the Velocity of Wave Propagation in a Universal Gaseous Medium.

E. L. LARKIN: Condition of Seeing, etc., at Lowe Observatory.

The following grants have been made by the Rumford Committee of the American Academy of Arts and Sciences: To Dr. R. S. MINOR, $250 for a research on the dispersion and absorption of ultra-violet radiations; to Dr. S. D. TOWNLEY, of Ukiah, Cal., $100 for a stellar photometer; to Professor E. B. FROST, of the Yerkes Observatory, $200 for a special lens to be used in connection with the Bruce spectrograph in the study of velocities in the line of sight; to Professors E. F. NICHOLS and G. F. HULL, of Dartmouth College, $250 for a research on the relative motion of earth and ether; to Professor GEORGE E. HALE, of the Yerkes Observatory, $300 for a Rowland grating to be used in studying the spectra of the brightest stars.

During the illness of Professor JOHN K. REES, who has taken a leave of absence until next fall, Professor HAROLD JACOBY is in charge of the Astronomical department at Columbia University. Dr. CHARLES L. POOR, formerly associate professor of astronomy at the Johns Hopkins University, has been appointed lecturer in astronomy at Columbia University. Dr. SIDNEY D. TOWNLEY, of the University of California, has been appointed observer at the International Latitude Station at Ukiah. Doctor TOWNLEY will take charge of the station on May 1st; from February 1st until this later date the time will be spent in alternate observing by Doctor TOWNLEY and the present observer for the purpose of determining whether a change of observers will have any apparent effect upon the latitude. The vacancy caused by Doctor TOWNLEY'S resignation from the Berkeley Astronomical Department of the University of California has been filled by the appointment of Doctor RUSSELL TRACY CRAWFORD, examiner to the U. S. Civil Service Commission.

Doctor CHARLES DUFOUR, professor of astronomy at Lausanne, Switzerland, is dead. On January 16th, died Professor E. A. FUERTES, Director of the A. C. Barnes Astronomical Observatory at Cornell University. Professor FUERTES was born in Porto Rico in 1838; he was much more prominent in engineering than in astronomy. Professor WILLIAM HARKNESS, late Director of the Nautical Almanac, and one of the most prominent of American astronomers, died on February 28th; we hope to give later a sketch of his career.

For the following accounts of Sir G. G. STOKES and of JAMES GLAISHER, who died recently in England, we are indebted to Mr. ANDREW GREIG, of Dundee, Scotland:—

"Sir GEORGE GABRIEL STOKES, of Cambridge, England, died 1st February, 1903. It was in 1841 that he took his degree as Senior Wrangler. In 1849 he was elected to fill the chair of Lucasian Professor of Mathematics at Cambridge—once occupied by NEWTON; and three years after became a Fellow of the Royal Society, and from 1885 to 1890 he acted as President of that distinguished body. No occupant of NEWTON'S office so closely resembled the great master. In the quality and direction of their studies, in the perfection of their analysis, and in the devout reverence for the cause of causes in Nature, they were men of the same order. STOKES'S favorite study was the science of light. It was said of him that 'if you give STOKES three-quarters of an hour of sunlight, there is no experiment in optics that he cannot perform for you.'. He received two medals from the Royal Society; held honorary degrees of several universities; and was President of the British Association in 1869.

" Sir GABRIEL STOKES was one of the foremost mathematicians of his time. Among scientific men of his generation he stood very high. Lord KELVIN once called him 'the teacher and guide of his contemporaries,' and the esteem in which he was held in the world of learning was abundantly illustrated on the occasion of his jubilee as Lucasian Professor in 1899, when the principal Universities of the Old and New World sent their most distinguished savants to do honor to the event. His researches into optics and the spectrum analysis, his investigation into the variation of gravity over the Earth's surface, and his enunciation of the laws of fluorescence, placed him in the front rank of nineteenth century scientists. His papers on these and many other subjects are pronounced to be 'perfect in form and unassailable in accuracy.' He died at the ripe old age of 83."

"At the ripe age of 93 there has just died Mr. JAMES GLAISHER, F.R.S., for many years Superintendent of the Magnetical and Meteorological Department of the Royal Observatory, Greenwich, and a scientist of no mean attainments. His special study was meteorology, and in the pursuit of his investigations he made the famous seven-mile balloon ascent with the late Mr. HENRY COXWELL, when both aeronauts narrowly escaped with their lives. Mr. GLAISHER was born in London in April, 1809, and was barely 20 years old when he received an appointment in connection with the Ordnance Survey of Ireland. He made close observations respecting the formation and the colors of clouds, subsequently publishing a book on the subject. In 1833 he became an assistant at Cambridge Observatory, and three years later assistant in the Astronomical Department of the Royal Observatory at Greenwich, while in 1840 he was appointed superintendent of the newly formed Magnetic and Meteorological Department at Greenwich. That post he continued to hold until his retirement from the public service 34 years later. Among other things he did in this position was to begin, in 1841, the publication of those quarterly and annual reports on meteorology which have been regularly issued by the Registrar-General ever since. Mr. GLAISHER wrote more than 100 books and papers on astronomy, meteorology, and the theory of numbers."

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD IN THE ROOMS OF THE SOCIETY, MARCH 28, 1903, AT 7:30 P.M.

President Perrine presided. A quorum was present. The minutes of the last meeting were read and approved. The following members were duly elected:—

LIST OF MEMBERS ELECTED MARCH 28, 1903.

Mr. Geo. A. Batchelder	Menlo Park, Cal.
Mr. H. C. Chesebrough	300 California St., S. F., Cal.
Dr. Russel Tracy Crawford	Students' Observatory, Berkeley, Cal.
Mr. Ralph Curtiss	Lick Observatory, Mt Hamilton, Cal.
Mr. E. A. Denicke	1000 Mason St., S. F., Cal.
Mr. R. H. E. Espey	Room 4, 4th floor Mills Building, S. F., Cal.
Dr. A. F. Gillihan	Students' Observatory, Berkeley, Cal.
Mr. H. T. S. Green	London, Paris & American Bank, S. F., Cal.
R Waldo Harrison	165 Clinton Ave., Jersey City, N. J.
Mr. Garrett W. McEnerney	Nevada Block, S. F., Cal.
Mr. James D. Phelan	Phelan Building, S. F., Cal.
Mrs. E. T. Schild	1908 Broadway, S. F., Cal.
Dr. M. Schirman	Rooms 426–427, Emma Spreckels Building, S. F., Cal.
Mr. S. E. Slade	6 California St., S. F., Cal.
Mr. A. B. Spreckels*	327 Market St., S. F., Cal.
Mr. Joel Stebbins	Lick Observatory, Mt. Hamilton, Cal.
Mr F. W. Van Sicklen	1831 Central Ave., Alameda, Cal.
Mr. J. H. G. Wolf	92 Flood Building, S. F., Cal.

REPORT OF THE LIBRARY COMMITTEE.

The Library Committee presented its report, as follows, and the report was accepted and filed:—

San Francisco, Cal., March 28, 1903.

To the Board of Directors of the Astronomical Society of the Pacific:—

We, the undersigned Committee of the Society's Library, report as follows:—

Since the last written report, two years ago, several changes have been made in the Library; a set of shelves and a chest of drawers have been added to the equipment, the books and pamphlets have been rearranged, many incomplete volumes and sets completed, the accessions book and the card catalogue checked up, and a good start made toward the preparation of the catalogue authorized by the Board of Directors at the meeting of November 30, 1902.

By binding, purchase, and gift the number of volumes in the accessions book has been increased in the last two years from 1,144 to 1,258. There are also about forty volumes at the bindery, which makes a total of 1,300 bound volumes in the Society's Library.

The expenditures from the Alexander Montgomery Library Fund may be found in the Treasurer's report.

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* Signifies life membership.

The Committee wishes to express its indebtedness to Miss ADELAIDE HOBE, a member of the Society, who kindly spent several days during the Christmas holidays aiding the Committee in rearranging the books and in checking up the accessions book and the card catalogue.

Respectfully submitted,

SIDNEY D. TOWNLEY, *Librarian.*
ROSE O'HALLORAN.

The following resolutions were adopted:—

Resolved, That the sum of $5,000, constituting the bequest to the Society by the late Mr. JOHN DOLBEER be transferred from the General Fund to a separate fund, to be known as the JOHN DOLBEER FUND of the Astronomical Society of the Pacific.

It was, upon motion by the Treasurer,

Resolved, That the funds of the Society, with the exception of the General Fund, be placed under the immediate care of the Finance Committee, and that moneys belonging to such funds shall be withdrawn only upon orders or receipts signed by at least a majority of the members of said Finance Committee, and that a copy of this resolution, duly certified by the President and Secretary, be delivered to the banks holding such deposits.

It was, upon motion by Mr. CUSHING,

Resolved, That the Finance Committee be empowered to invest the funds of the Society, upon the consent of the President, in such first-class bonds as they may deem advisable.

Resolved, That the dates of issue of the *Publications* be changed from the 1st to the 10th of the months of February, April, June, August, October, and December.

AMENDMENT TO THE BY-LAWS.

The following amendment to the By-Laws was duly adopted by the consenting votes of nine Directors, namely:—

Messrs PERRINE, LEUSCHNER, CUSHING, BABCOCK, AITKEN, CAMPBELL, PIERSON, MOLERA, ZIEL.

ARTICLE IX.

The annual meeting of this Society shall be held on the last Saturday in March, at 8 o'clock P. M., at the rooms of the Society in San Francisco; and meetings shall be held for the ordinary transactions and purposes of the Society, as follows:—

Meetings shall be held in the Library of the Lick Observatory, Mount Hamilton, at a suitable hour on the last Saturdays of June and August; and meetings shall be held in the rooms of the Society, in San Francisco, at 8 o'clock P. M., on the last Saturdays of January, March, and November.

A special meeting may be called by the President, or, in his absence or disability, by one of the Vice-Presidents, or, in the absence or disability of the President and the Vice-Presidents, by the Secretary, on the written requisition of ten active or life members; and the object of such meeting shall be stated in the notice by which it is called.

The annual election shall be held on the day of the annual meeting, between the hours of 8:15 and 9 P. M.

No member shall be permitted to vote at any meeting of the Society who has not paid all his dues for past and current years. There shall be no voting by proxy.

Adjourned.

MINUTES OF THE FIFTEENTH ANNUAL MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD IN THE LECTURE HALL OF THE CALIFORNIA ACADEMY OF SCIENCES, MARCH 28, 1903, AT 8 P. M.

The meeting was called to order by President Perrine. A quorum was present. The minutes of the last meeting were approved. The Secretary read the names of new members duly elected at the Directors' meeting.

The following papers were presented:—

1. Address of the retiring President of the Society, by C. D. Perrine.
2. Reports of Committees; on Nominations; on the Comet Medal; on the Library; on Auditing; and Annual Report of the Treasurer.
3. The D. O. Mills Expedition to Chile, by W. W. Campbell.
4. Astronomical Observations at Odder, Denmark, in 1902, by Torvald Köhl.
5. The Parallax of *Delta Equulei*, by W. J. Hussey.
6. Observations of Variable Stars, by Miss Rose O'Halloran.
7. The Orbit of *Epsilon Hydræ*, AB., by R. G. Aitken.
8. Planetary Phenomena for May and June, 1903, by Malcolm McNeill.

The Committee on Nominations reported a list of names proposed for election as Directors, as follows: Messrs. R. G. Aitken, Chas. Burckhalter, W. W. Campbell, Wm. H. Crocker, Chas S. Cushing, O. von Geldern, A. O. Leuschner, E. J. Molera, Wm. M. Pierson, S. D. Townley, F. R. Ziel.

For Committee on Publication: Messrs. R. G. Aitken (Chairman), Frank Schlesinger, S. D. Townley.

Messrs. Babcock and von Geldern were appointed as tellers. The polls were open from 8:15 to 9 P. M., and the persons above named were duly elected to serve for the ensuing year.

REPORT OF THE COMMITTEE ON THE DONOHOE COMET-MEDAL.

Submitted March 28, 1903.

This report relates to the Calendar year 1902. The Comets of 1902 have been:—

Comet *a* (unexpected comet) discovered by W. R. Brooks at Geneva, N. Y., on April 14th.

Comet *b* (unexpected comet) discovered by C. D. Perrine at the Lick Observatory on September 1st.

Comet *c* (unexpected comet) reported by John Grigg of Thames, New Zealand, as having been seen by him first on July 23d. This comet appears to have escaped detection by other observers.

Comet *d* (unexpected comet) discovered by M. Giacobini at Nice on December 2d.

In accordance with the statutes, Donohoe Comet-Medals have been awarded to the discoverers of Comets *a*, *b*, and *d*.

W. W. Campbell,
Chas. Burckhalter,
Wm. M. Pierson,
Committee on the Donohoe Comet-Medal.

The Treasurer submitted his Annual Report as follows:—

ANNUAL STATEMENT OF THE RECEIPTS AND EXPENDITURES OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC FOR THE FISCAL YEAR ENDING MARCH 28, 1903.

GENERAL FUND.

Receipts. (March 30, 1902, to December 31, 1902.)

1902, March 30th. Cash Balance			$77 27
Received from dues for 1892 and previous years	$206 62		
" " " " 1903	40 00		
" " Life membership fee	50 00	$296 62	
" " sale of publications		72 58	
" " " " stationery		1 00	
" " Bruce Medal Fund (loan of March 8, 1900, returned)		81 62	
" " Contribution by Mr. WM. ALVORD		100 00	
" " " " " WM. M. PIERSON		475 00	
		$1,026 82	
Less transfer to Life Membership Fund		50 00	976 82
			$1,054 09

Expenditures. (March 30, 1902, to December 31, 1902.)

For Publications: printing Vol. XIV	$566 15		
illustrations	16 45	$582 60	
Stationery and printing		81 30	
Postages		56 41	
Rent		135 00	
Salary Secretary-Treasurer		135 00	
Expressages		8 85	
Telephone		50	
Janitor		4 00	
Gas		3 90	
Insurance premiums		22 75	
Carpenter and locksmith		1 00	
Lecturer's traveling expenses		12 50	
Lantern at lecture		8 00	1,051 81
1902, December 31st. Cash Balance			$2 28

Receipts. (January 1 to March 28, 1903.)

Received from dues for 1903	$552 02		
" " " " previous years	90 00	$642 02	
" " Security Savings Bank (interest)		17	
" " Life Membership Fund (interest)		53 76	
Bequest received from Estate of JOHN DOLBEER		5,000 00	5,695 95
			$5,698 23

Expenditures. (January 1 to March 28, 1903).

For Publications: printing No. 88 of Vol. XV	$126 55	
Stationery and printing	54 00	
Postages	10 60	
Rent	45 00	
Salary Secretary-Treasurer	45 00	
Expressages	25	
Janitor	1 00	
Gas	1 00	
Bank exchanges	15	283 55
1903, March 28th. Cash Balance		$5,414 68

LIFE MEMBERSHIP FUND.

1902, March 30th. Cash Balance	$1,653 95
Received from General Fund	50 00
Interest for 1902	53 76
	$1,757 71
Less transfer to General Fund (interest)	53 76
1903, March 28th. Cash Balance	$1,703 95

DONOHOE COMET-MEDAL FUND.

1902, March 30th. Cash Balance	$685 47
Interest for 1902	22 11
	$707 58
Less engraving medals Nos. 41 and 42	2 00
1903, March 28th. Cash Balance	$705 58

BRUCE MEDAL FUND.

1902, March 30th. Cash Balance		$2,554 07
Interest for 1902		76 84
		$2,630 91
Less remittance to A. DuBois, balance of fourth award	$ 50	
" advance of March 8, 1900, returned to General Fund	81 62	82 12
1903, March 28th. Cash Balance		$2,548 79

ALEXANDER MONTGOMERY LIBRARY FUND.

1902, March 30th. Cash Balance		$1,559 39
Interest for 1902		49 26
		$1,608 65
Less expenditures:		
Mueller: Photometrie der Gestirne,	$10 62	
Scheiner: Photographie der Gestirne,		
Byrd: Laboratory Manual in Astronomy,	17 90	
Comstock: Method of Least Squares,		
Doolittle: Treatise on Practical Astronomy,		
Morton: Heroes of Science,		
Dreyer: Tycho Brahe,		
Lodge: Pioneers of Science,		
Comstock: Textbook of Astronomy,		
Howe: Elements of Descriptive Astronomy,		
Todd: New Astronomy,		
Richards: Navigation and Nautical Astronomy,		
Newcomb: The Stars,		
Jacoby: Practical Talks by an Astronomer,		
Moulton: Celestial Mechanics,	4 75	
Brickerton: Romance of the Earth,		
" " " " Heavens,		
Valentiner: Handwoerterbuch der Astronomie (4 vols.)	23 34	
Hicks-Judd Co., binding	29 40	
Astronomical Journal, Vol. 23	5 00	
Popular Astronomy, Vol. 11	2 50	93 51
1903, March 28th. Cash Balance		$1,515 14

FUNDS.

Balances on Deposit as follows:

General Fund:		
with Donohoe-Kelly Banking Co	$ 414 68	
" Union Trust Co.	2,500 00	
" Mutual Savings Bank	2,500 00	$5,414 68
Life Membership Fund:		
with San Francisco Savings Union	$653 95	
" German Savings and Loan Society	450 00	
" Hibernia Savings and Loan Society	600 00	$1,703 95
Donohoe Comet-Medal Fund:		
with San Francisco Savings Union	$221 45	
" German Savings and Loan Society	237 68	
" Hibernia Savings and Loan Society	246 45	$705 58
Alexander Montgomery Library Fund:		
with San Francisco Savings Union	$439 84	
" German Savings and Loan Society	424 48	
" Hibernia Savings and Loan Society	650 82	$1,515 14
Bruce Medal Fund:		
with San Francisco Savings Union	$1,268 83	
" Security Savings Bank	638 37	
" German Savings and Loan Society	641 59	$2,548 79
		$11,888 14

SAN FRANCISCO, March 28, 1903.

F. R. ZIEL, *Treasurer.*

Examined and found correct.

CHAS. S. CUSHING, } *Auditing Committee.*
L. H. PIERSON,

The report was, on motion, accepted and filed.

The Committee appointed to audit the Treasurer's accounts reported as follows, and the report was, on motion, accepted and adopted:—

SAN FRANCISCO, CAL., March 28, 1903.

To the President and Members of the Astronomical Society of the Pacific:

GENTLEMEN — Your committee appointed to audit the accounts of the Treasurer for the fiscal year ending March 28, 1903, has, after a careful examination, found the same to be correct.

Respectfully submitted,

CHAS. S. CUSHING, } *Committee.*
L. H. PIERSON,

The President then read his annual address.

Professor LEUSCHNER read Professor HUSSEY'S paper on the Parallax of *Delta Equulei;* and Mr. BABCOCK read Professor CAMPBELL'S paper on the D. O. Mills Expedition to Chile. President PERRINE then replied to questions put by members of the Society.

The following resolution was, on motion, adopted:—

Resolved, That all the acts appearing in the minutes of the meetings of the Board of Directors of this Society, as having been done by said Board during the past fiscal year, are here now, by this Society, approved and confirmed.

Adjourned.

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD IN THE ROOMS OF THE SOCIETY, MARCH 28, 1903, AT 9:30 P.M.

The new Board of Directors was called to order by Mr. BURCKHALTER. A quorum was present. The minutes of the last meeting were approved.

The business in hand being the election of officers and committees for the ensuing year, the following officers and committees, having received a majority of the votes cast, were duly elected:—

President: Mr. VON GELDERN.
First Vice-President: Mr. S. D. TOWNLEY.
Second Vice-President: Mr. W. W. CAMPBELL.
Third Vice-President: Mr. CHAS. S. CUSHING.
Secretaries: Messrs. R. G. AITKEN and F. R. ZIEL.
Treasurer: Mr. F. R. ZIEL.

Committee on the Comet-Medal: Messrs. CAMPBELL (*ex-officio*), PIERSON, and BURCKHALTER.

Library Committee: Messrs. TOWNLEY, RICHARDSON, Miss O'HALLORAN. Mr. TOWNLEY was appointed Librarian.

Finance Committee: Messrs. PIERSON, CUSHING, LEUSCHNER.

The Committee on Publication is composed of: Messrs. R. G. AITKEN (*Chairman*), FRANK SCHLESINGER, S. D. TOWNLEY.

The Board of Directors is composed of: Messrs. AITKEN, BURCKHALTER, CAMPBELL, CROCKER, CUSHING, VON GELDERN, LEUSCHNER, MOLERA, PIERSON, TOWNLEY, and ZIEL.

Adjourned.

OFFICERS OF THE SOCIETY.

Mr. von Geldern	*President*
Mr. S. D. Townley	*First Vice-President*
Mr. W. W. Campbell	*Second Vice-President*
Mr. Chas. S. Cushing	*Third Vice-President*
Mr. R. G. Aitken Mr. F. R. Ziel	*Secretaries*
Mr. F. R. Ziel	*Treasurer*

Board of Directors—Messrs. Aitken, Burckhalter, Campbell, Cushing, Leuschner, Molera, Crocker, von Geldern, Pierson, Townley, Ziel.

Finance Committee—Messrs. Pierson, Cushing, Leuschner.

Committee on Publication—Messrs. Aitken, Schlesinger, Townley.

Library Committee—Mr. Townley (*Librarian*). Richardson, O'Halloran.

Committee on the Comet-Medal—Messrs. Campbell (*ex-officio*), Pierson, Burckhalter,

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. Ruthven W. Pike.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. Felipe Valle.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.

(February, April, June, August, October, December.)

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PUBLICATIONS

OF THE

ASTRONOMICAL SOCIETY

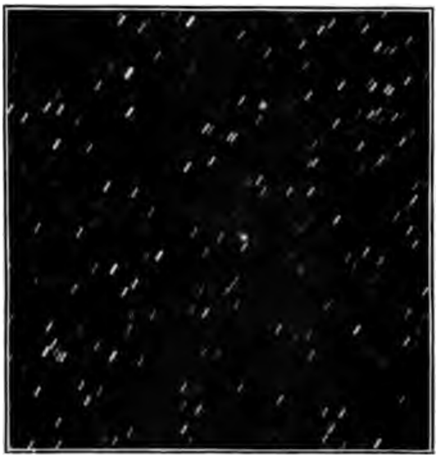
OF THE PACIFIC.

Stanford University Library

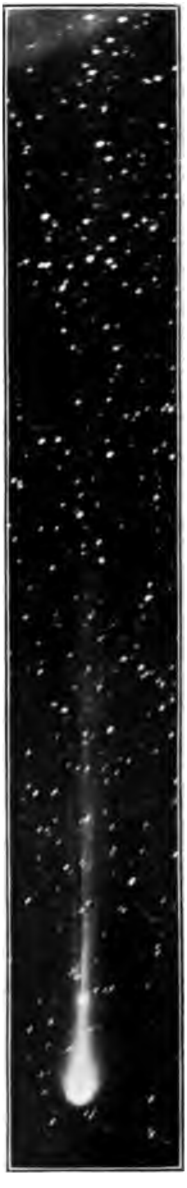
VOLUME XV.
NUMBER 90.
1903.

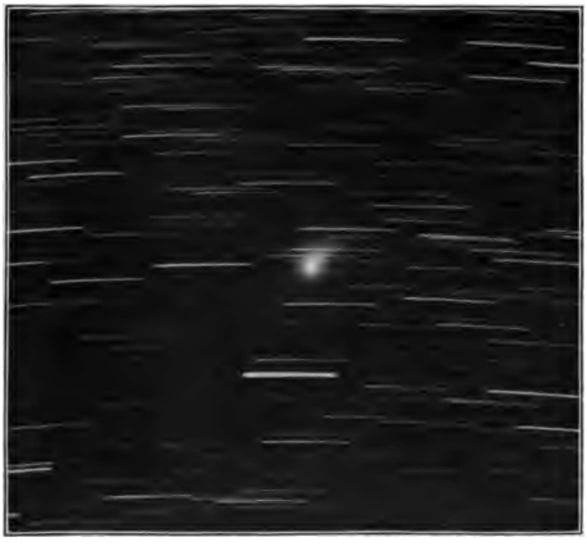
SAN FRANCISCO:
PRINTED FOR THE SOCIETY.
1903.

[Entered at Post Office at San Francisco, Cal., as second-class mail matter.]



1902. Sept. 3





1902. Sept. 30

1902. Oct. 31

COMET b, 1902 (PERRINE)

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. XV. SAN FRANCISCO, CALIFORNIA, JUNE 10, 1903. NO. 90.

PHOTOGRAPHIC OBSERVATIONS OF COMET *b* 1902 (PERRINE).

By R. H. CURTISS.

At the time of its discovery, September 1, 1902, this comet was of the 9th magnitude, with a fairly sharp nucleus of magnitude 10½ or 11. As the preliminary orbit predicted an interesting career for the visitor, it was decided to make a series of photographs at intervals, depending upon the degree of activity developed.

For this work the Pierson (Dallmeyer) camera of 15^{cm} aperture and 82.6^{cm} equivalent focal length seemed best adapted, the more so because of its superior driving and guiding facilities. This instrument is mounted in parallel with the Floyd telescope of 12.5^{cm} aperture and 200^{cm} focal length, and the combination is carried by a Warner & Swasey mounting. The Floyd is provided with a guiding eye-piece with adjustable electrical illumination. Though of rather high power, this eye-piece has been found particularly useful in guiding on faint objects. In the case of this comet, the intersection of two fine cross-wires was the reference-point in guiding.

As the comet brightened, it was decided to make simultaneous large-scale photographs with the Floyd telescope, which may be adapted for photographic purposes by reversing the crown-lens. The focal length is then 178^{cm}. An additional telescope of 7^{cm} aperture and 95^{cm} focal length was added to the combination, the guiding arrangements being transferred to this smaller instrument.

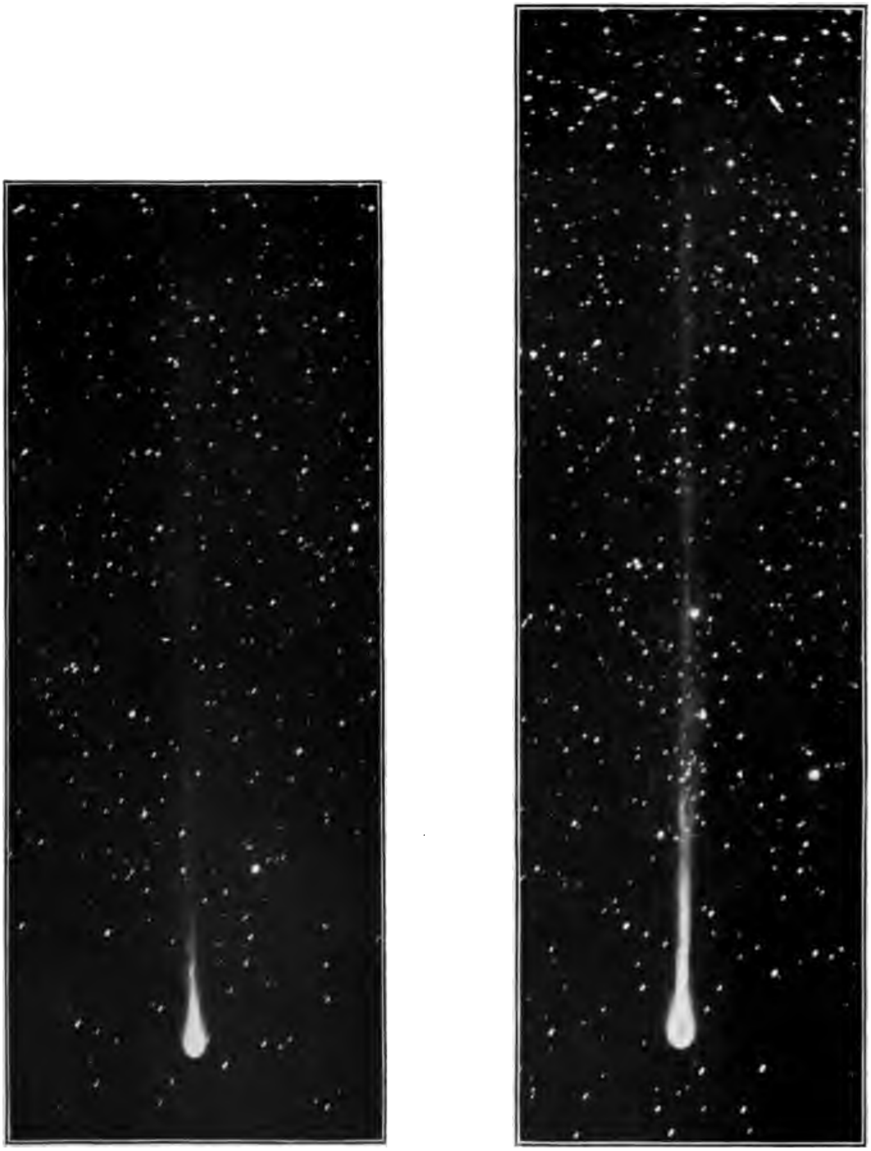
The scale of the negatives reproduced is 0°.693 per cm at the center of plate, and, at the distance (d) in cm from the center, the scale value is $\frac{4730}{6820+d^2}$ degrees per cm. In all the copies the scale of the original has been preserved.

In all, eighteen exposures were made in a total of fifty hours. Eighteen negatives were secured with the Pierson camera and fourteen with the Floyd. The exposure on any night was as long as circumstances would allow, ranging from 25 minutes to 6 hours.

Owing to uncertainties incident to varying sky and unequal exposures, and because of the difficulty of assigning any definite termination to a gradually fading comet-tail, a detailed study of the changes in the length of the tail is perhaps of little interest. The accompanying cuts will illustrate in a general way the nature of such changes. With an exposure of four hours on September 3d, the length of the tail recorded is 3^{mm}; on September 25th, 2^{cm}. On October 7th the longer tail can be traced for 7^{cm}, and finally, in the latter part of October, it runs clearly to the edge of the plate, a distance of 16^{cm}, or 11°, through regions blurred by aberration. On November 1st, the tail of this comet was certainly more than sixteen million miles long.

The changes in structure of the tail between successive exposures are most interesting on the plates after October 7th. In the case of the earlier negatives no clear details are to be expected, on account of the faintness of the tail and the changes in its form during the long exposures. The secondary tail is clearly seen on the first negative of long exposure (September 3d). The primary tail appears very nearly straight on all the plates while the other is curved and much shorter than the straight tail, though nearly as bright. On the plate of October 7th, the secondary tail is clearly identified for the last time.

The negatives from October 25th to November 2d, inclusive, show much interesting detail. The comet at that time was within a month of perihelion passage, and therefore in very active condition. With the purpose of determining the velocity of motion of any given point in the tail with reference to the head, I have tried to identify any condensation or configuration on successive nights, but so complete was the change in a day that nothing of the kind was possible.



1902. Nov. 1　　1902. Nov. 2

COMET b, 1902 (PERRINE)

The plate of October 25th shows three main streamers, of which the central one is brightest and longest. The tail splits up into two streams close to the head. The fainter one is straight, while the brighter one curves away a little and divides into two straight streamers. On the following night the fainter streamer has nearly disappeared. No other streamers appear, but the main tail suddenly spreads about 3^{cm}, or 2°, from the head to six times its width near the coma, and a rift appears in the center of this thicker portion. On October 27th several new streamers appear. On the negative of October 31st as many as eight distinct streamers can be seen. They extend about 7^{cm} from the head, while the main tail continues 16^{cm} to the edge of the plate. On the following night these streamers have faded, while on November 2d there is but one connected with the main tail, which has straightened out to a narrow bright streamer of varying width.

On the earlier negatives, the nucleus is sharp and clearly defined. It is surrounded with a layer of nebulous matter. As the comet approaches the Sun, the nucleus spreads, and the layer of nebulous matter seems to diminish in thickness while a heavy fan-shaped spray appears on the side of the head away from the Sun.

A table of exposures appears below. After September 25th, negatives were made simultaneously with the Pierson and Floyd cameras. The times of beginning and ending are expressed in Pacific standard time:—

Date.	Beginning.	End.
1902.		
September 1...	12.40	13.05
3...	12.10	16.33
10...	12.08	16.10
25...	8.10	12.50
30...	11.42	16.42
October 3...	9.15	15.00
4...	9.26	15.25
7...	10.05	14.25
25...	7.00	8.45
1902.		
October 26...	6.45	8.35
27...	6.32	8.23
28...	6.25	8.13
29...	6.27	8.07
31...	6.19	7.54
November 1...	6.25	7.40
2...	6.25	7.32
4...	6.35	7.15
5...	6.37	7.00

PLANETARY PHENOMENA FOR JULY AND AUGUST, 1903.

By Malcolm McNeill.

PHASES OF THE MOON, PACIFIC TIME.

First Quarter,	July	1,	1^{h} 2^{m} P.M.	Full Moon,	Aug.	8,	12^{h} 54^{m} A.M.
Full Moon,	"	9,	9 43 A.M.	Last Quarter,	"	15,	9 22 P.M.
Last Quarter,	"	17,	11 24 A.M.	New Moon,	"	22,	11 31 A.M.
New Moon,	"	24,	4 46 A M.	First Quarter,	"	29,	12 34 P.M.
First Quarter,	"	30,	11 15 P.M.				

The Earth is in aphelion on the evening of July 2d.

Mercury is not in very favorable position for naked-eye view during July and August. At the beginning of July it is a morning star, having passed greatest west elongation late in June, but the interval between the rising of the planet and sunrise is only a little more than one hour. The interval remains as great as one hour until about the middle of the month, and it is possible that the planet may be seen in especially good weather. After the middle of the month the planet rapidly approaches the Sun, and passes superior conjunction July 26th. Throughout August it is an evening star, and toward the close of the month it is nearly at its greatest east elongation, but the relatively great southern declination of the planet allows it to remain above the horizon less than an hour after sunset, and thus makes the conditions for visibility decidedly poor.

Venus is still an evening star, and reaches its greatest east elongation, 45° 30′, on July 9th; but after that its distance from the Sun diminishes very rapidly, and by the end of August it has nearly reached inferior conjunction. On July 1st it sets about 2^{h} 35^{m} after sunset, on August 1st, 1^{h} 45^{m} after, and on September 1st, only 22^{m} later. The planet is now in that part of its orbit farthest south of the ecliptic, and this contributes materially toward diminishing the interval between the setting of the Sun and of the planet. *Venus* will, however, come to its greatest brightness on August 12th, and for some weeks before and after that time will be visible in full sunlight, if one knows where to look for it. *Mercury* and *Venus* are in conjunction on August 28th, with *Venus* a little more than 6° south of *Mercury*.

Mars is still in fair position for evening observation in the western sky. On July 1st it sets a little before midnight and two months later, on September 1st, it sets shortly after 9 o'clock. Its distance from us in millions of miles increases from 104, on July 1st, to 122, on August 1st, and 139, on September 1st, and in consequence its brightness diminishes more than fifty per cent during the interval; but it will still be bright enough to be rather conspicuous among the stars, and it will not be at all difficult to identify. Its motion among the stars during July and August is about 32° eastward and 13° southward from the western part of the constellation *Virgo* into *Libra*. On July 23rd it passes about three diameters of the Moon north of *Spica, α Virginis*. On July 1st it is in conjunction with the Moon, and on the evening of that day the Moon will pass just south of the planet. The planet will be occulted in countries farther south than the United States, and perhaps in the extreme southern parts of this country.

Jupiter is moving around toward a position favorable for evening observation. It rises shortly after 11 P. M. on July 1st, and by the end of August shortly after seven. It is in the constellation *Pisces*, and moves slowly eastward, about 15′, until July 14th. It then begins to move westward, and by the end of August this retrograde motion amounts to about 3°. In its retrograde motion it follows a path a fraction of a degree south of its eastward path, and at the end of August its position is about the same as it was at the end of May.

Saturn is in good position for observation. It comes to opposition with the Sun on July 30th, and is consequently above the horizon nearly the entire night throughout the two months. It is in the constellation *Capricorn*, and moves about 5° westward during July and August. Both *Saturn* and *Jupiter* are in a region in which there are few bright stars.

Uranus is above the horizon until late at night, not setting until about 3:30 on July 1st, and shortly after 11 on September 1st. It moves westward until the end of August a little more than 1° in *Ophiuchus* between *Scorpio* and *Sagittarius*, but no bright star is near enough to afford an easy identification.

Neptune passed conjunction with the Sun late in June, and is now a morning star, but until August it remains too near the Sun to be easily seen even with a good telescope.

August is the month for the *Perseid* meteors, and the watcher for them will be able to see a good many during any clear night, especially during the second week of the month.

AN APPLICATION OF THE CROSSLEY REFLECTOR OF THE LICK OBSERVATORY TO THE STUDY OF VERY FAINT SPECTRA.*

By H. K. Palmer.

While engaged in photographing the brighter nebulæ with the Crossley reflector, the late Professor **Keeler** noted the great relative photographic brightness of the central stars in the ring nebulæ in *Lyra* and *Cygnus*—a fact indicating that the spectra of these stars contain an unduly large proportion of actinic rays. He tried to examine their spectra, both with a direct-vision spectroscope and with a prism held in the path of the rays, but in neither case was the spectrum bright enough to be seen. He therefore decided to construct a spectrograph for the study of these objects.

Such an instrument, to preserve and utilize the enormous advantages of the silver-on-glass reflecting telescope for work in the violet and ultra-violet regions, called for a design radically different from those of conventional spectroscopes. It would evidently be difficult for a star near the limits of vision to be centered and kept upon a narrow slit; the method of guiding by means of a reflecting slit would not answer; and it would be important to avoid the usual losses due to a slit. The instrument as originally designed consisted, in outline, of a 50° quartz prism with circular aperture of 27^{mm}, placed directly in the converging beam of light from the great mirror, at a distance of 15^{cm} inside the focus; of a plate-holder suitably placed; and of a guiding eye-piece working on the same principle as that employed in ordinary nebular photography.

Director **Keeler** had thought that by placing the prism approximately at minimum deviation for the ray coinciding with the collimation axis, the confusion in the image, due to the very large angle of the cone of incidental light, would be so slight as not to interfere with the qualitative purposes of the instrument; especially since the dispersion would be small—only 3^{mm} from λ 350 to λ 500. It should be said, however, that he had doubts as to the success of this plan, but felt that it would be well worth a trial.

---

* Abstract from Lick Observatory Bulletin No. 34.

The spectograph was constructed by the observatory instrument-maker. It was completed on the day Professor KEELER left Mt. Hamilton for the last time, about a fortnight before his death.

A few weeks thereafter Dr. CAMPBELL and I tried the spectrograph, and found that the beam of light could not be brought to a focus. On account of the approaching opposition of *Eros*, and the plans for completing, if possible, Professor KEELER's program of photographing the brighter nebulæ during the following spring, the instrument was set aside until April, 1901.

Director CAMPBELL then asked me to design such changes in the instrument as would permit the insertion of a double concave quartz lens immediately in front of the prism, and of a double convex similar lens immediately behind the prism to receive the refracted rays and form the image on the sensitive plate. The lenses were constructed by the John A. Brashear Co., from constants supplied by Professor WADSWORTH. These additions to the optical train necessitated several changes in the support of the plate, in the guiding fixtures, etc. The alterations were completed by the instrument-maker on June 3d, and to me was assigned the duty of testing its capabilities.

It is only possible here to give a brief summary of the observations and the conclusions to which they have led, referring the reader to the original paper in Lick Observatory *Bulletin* No. 34 for the details, as well as for the full description, of the apparatus, its adjustments, and the method of observing.

As soon as the spectrograph was completed and adjusted, photographs were taken of the spectra of various objects to find out for what work an instrument of this kind is best adapted; and to determine its limitations. It is evident that, because of the small dispersion, it cannot as a rule be used to advantage on the dark-line spectra, but some stars have been photographed with dark bands, broad enough to show. This limits it very largely to bright-line spectra, though it has great value for determining the nature of very faint spectra of all kinds. Moreover, since there is no slit, the object must not be so large that the various monochromatic images will overlap too much, and this condition confines the field to objects no larger than planetary nebulæ.

Large numbers of objects having various spectral types promised to yield valuable results; but on account of the limited time at my command, my program was confined, with the director's approval, to comparatively few objects. These included:—

(*a*) Such planetary nebulæ as were in observing position, both for purposes of comparison with results reached by observers using other instruments, and in the hope of discovering new features in the ultra-violet region. It was not expected that results obtained in the $H\epsilon$—$H\beta$ region of bright objects, by observers using large telescopes and powerful spectroscopes, would be surpassed or even equaled, on account of the feeble dispersion of this instrument.

(*b*) Such new stars as were in observing position.

(*c*) The central star in the ring nebula in *Lyra,* and other similar stars and stellar nuclei.

(*d*) A few Wolf-Rayet stars.

Altogether, twenty-one nebular spectra were photographed by me between June and September, 1901. After my departure, Mr. JOEL STEBBINS, Fellow in the Lick Observatory, kindly secured for me with the same instrument some very good spectrograms of *Nova Aurigæ, Nova Persei,* and a Wolf-Rayet star.

Examination of these spectrograms shows that in general the intensity of the continuous spectrum of the nebulæ has a minimum between $H\delta$ and $H\gamma$. This fact is confirmed by nearly all the negatives, and is too general a characteristic to be passed without notice. It seemed hardly possible that the spectrum of the nucleus, to which it was supposed that this belonged, should have an absorption band at this place, and another explanation was sought. This was found by plotting Dr. CAMPBELL's observations of G. C. 4390 on the same scale, and comparing the result with the spectra obtained with the slitless spectrograph. His observations were made with a large spectroscope attached to the 36-inch refractor. Inspection of this spectrum showed that he found the bright lines much fewer in the region where the continuous spectrum is weak in the spectrograms taken with the small instrument. His observations of N. G. C. 7027 give the same results. From this it seems safe to infer that the apparently greater relative strength of my spectrograms in the $H\gamma$—$H\beta$ region is largely due to the presence of many faint overlapping bright lines, whereas, in the region $H\delta$—$H\gamma$ fewer bright lines exist. A further support of this theory is afforded by nebulæ N. G. C. 6826 and N. G. C. 6891, each of which has a stellar nucleus. In each case the spectrum of the necleus has an almost uniform intensity throughout its entire extent.

One of the marked advantages of the reflector and quartz prism and lenses over the great refractor and glass optical train in spectrum observations is revealed by this comparison. Even in the favorable nebula G. C. 4390, CAMPBELL's results stop at $H\zeta$, whereas the slitless spectrograph record extends to about λ 337.

One of the principal purposes of this investigation was to determine the efficiency of the slitless quartz spectrograph attached to the Crossley reflector, for the photography of very faint spectra. Its power in this respect is surprisingly great. It is well illustrated in the case of *Nova Cygni*. The visual magnitude of this star was estimated by Professor BARNARD in 1901 to be 15.5. My four-hour exposure, with fair following and focus, recorded its continuous spectrum in good strength, well up into the ultra-violet. The character of the spectrum could have been determined had the image been considerably less intense. This spectrum may be relatively stronger in the photographic regions than ordinary stellar spectra, though the spectra of many adjacent 15th-magnitude stars are recorded satisfactorily on the same plate. It would be perfectly practicable to carry the exposures up to ten hours or more; the guiding could be more accurate, now that the principal sources of the irregularity in diurnal motion have been removed;

and perhaps the more stable new telescope mounting will eliminate the present unfortunate changes in the focus during exposures. Considering these facts, I am reasonably confident that this instrument can record the continuous spectrum of the faintest star visible in the 36-inch telescope under the corresponding atmospheric conditions. Further, in the case of stellar nebulæ, etc., whose spectra contain well-defined bright lines, I do not doubt that the instrument will record the principal bright lines of objects too faint to be seen in our most powerful telescopes.

It is only for work on very faint spectra that this spectrograph is efficient. Its dispersive power is very low, and it should seldom be used on spectra, or on those portions of spectra bright enough to be recorded by relatively longer exposures with instruments giving greater dispersion.

For qualitative studies of general spectral features, this spectrograph is efficient on all spectra, whether continuous or bright line; but for quantitative results its usefulness is limited largely to small and faint bright-line spectra.

For most of the objects observed, a 60° prism, and for some of the objects two 60° prisms would have been an improvement over the present 50° prism; requiring, of course, the reconstruction of the instrument.

For some of the stellar bright-line objects a convex lens of twice the present lens's focal length would have had an advantage in separating close lines on the photographic plate, permitting at the same time more accurate determinations of wave-lengths. This would probably alter the character of the field of the combination somewhat.

It is possible that a similar instrument on twice the linear scale, *i. e.,* with lenses and prism having 50^{mm} apertures,—with perhaps a 60° prism,—would be efficient and practicable for the objects of medium brightness on my list.

New nebular lines at $\lambda\,337$ and $\lambda\,345$ were discovered. These lines were later found to exist in the spectrum of *Nova Persei,* from the plate taken October 14, 1901. The nebular character of the *Nova* spectrum is thus established for the extreme ultra-violet region, as had previously been done for the other regions.

The spectrum of *Nova Cygni,* which in 1876 was of the usual "new-star" type, and later changed into the nebular type, has now become continuous, with no signs of bright lines.

The bright lines in the nebular spectrum of *Nova Aurigæ* are now relatively faint, and the spectrum appears to be approaching the continuous type.

These complete and astonishingly rapid changes of spectral types observed in the cases of *Nova Cygni* and *Nova Aurigæ*,—and likewise those observed in *Nova Normæ, Nova Sagittarii, Nova Persei,* etc.,—leave little doubt that the masses of these objects are small.

All the new stars of recent years should be reobserved with this spectrograph every year, to keep account of the progressive changes in their spectra. The importance of carrying out this plan can scarcely be overestimated.

The relative intensities of nebular and other bright lines, as well as of continuous spectra, are shown more accurately on the plates secured with this spectrograph than on those made with instruments absorbing the blue and violet very strongly.

The spectrum of the central star in the ring nebula in *Lyra* seems to be not of an unusual type, unless perhaps it contains a bright line near λ 373. It is quite possible that the star is somewhat brighter photographically than visually; at least, photographic evidence is not opposed to this theory.

The great intensity of the λ373 ring in the ring nebula perhaps explains one point in nebular photography. Professor KEELER found that for most nebulæ an exposure of three hours gave the best results, whereas the best photograph of the ring nebula was obtained in ten minutes. While the ring nebula is brighter than the average bright nebula, this brief exposure of ten minutes is out of proportion to its visual brightness; but its radiation being mostly in the ultra-violet, it should have a somewhat greater photographic than visual brightness.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

CHANGES IN THE LICK OBSERVATORY STAFF.

Mr. HAROLD K. PALMER, Fellow in the Lick Observatory from July 1, 1898, to July 1, 1902, received the degree of Doctor of Philosophy from the University of California on May 14, 1903. Dr. PALMER holds the position of assistant in the Lick Observatory, with duties on the D. O. Mills Expedition to Chile. His thesis was on "An Application of the Crossley Reflector of the Lick Observatory to the Study of Very Faint Spectra."

Mr. JOEL STEBBINS, Fellow in the Lick Observatory from July 1, 1901, to July 1, 1903, received the degree of Doctor of Philosophy from the University of California on May 14, 1903. His thesis was on "The Spectrum of *Omicron Ceti.*" Dr. STEBBINS has been appointed Instructor in Astronomy in the University of Illinois, in charge of the observatory and department.

The two theses referred to above will be printed soon as Lick Observatory *Bulletins.*

Mr. SEBASTIAN ALBRECHT of the University of Wisconsin has been appointed Fellow in the Lick Observatory for the year beginning May 1, 1903.

Mr. ELLIOT SMITH of the University of Minnesota has been appointed assistant in the Lick Observatory on the Carnegie Institution foundation, with duties in the Meridian Circle Department.

W. W. C.

MRS. HEARST'S GIFT TO LICK OBSERVATORY.

Mrs. Phebe A. Hearst, Regent of the University of California, has generously contributed to the funds of the Lick Observatory for the present year in continuation of her contribution for the year 1902. This gift is available for improving the equipment of the observatory at various points.

W. W. C.

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* Lick Astronomical Department of the University of California.

THE VARIABLE STAR 10, 1903 *LYRÆ.*

In No. 3857 of the *Astronomische Nachrichten*, Professor SEELIGER announces the discovery by Herr E. SILBERNAGEL of a star near the ring nebula in *Lyra* which is either variable or a *Nova*. The discovery was made from photographs taken at the Munich Observatory.

The position of this star was sufficiently near to the ring nebula to be on the negatives of the latter obtained by Professor KEELER with the Crossley reflector in 1899. Several plates were taken on July 12th, 13th and 14th, with exposures ranging from 30 seconds to two hours. On all the negatives with exposures of 30 minutes and over 10, 1903 *Lyræ* is visible as a star of 17th magnitude. There is no perceptible difference in brightness on these plates.

On April 18 and 20, 1903, two photographs were secured, with exposures of one hour each. These plates show this star as 12th magnitude.

Photographs of its spectrum were secured on April 18th, 20th, 21st, and 24th, with the small slitless-spectrograph, designed by Professor KEELER, attached to the Crossley reflector. These negatives show the hydrogen lines $H\beta$, $H\gamma$, and $H\delta$ to be bright, together with bright lines at λ 463 and λ 446. There is a very strong continuous spectrum extending from $H\beta$ to above $H\delta$, and a weak spectrum in the ultra-violet.

A comparison of the spectrum of this star with that of *Nova Geminorum*, taken about the same time, shows that the hydrogen lines and λ 463 are of about the same relative intensity as in the *Nova;* while λ 446 and the continuous spectrum are very much stronger in the *Lyra* star.

A negative taken on an isochromatic plate shows, in addition, only the usual maximum at λ 570 which is characteristic of ordinary stars.

All of the facts at present known seem to indicate that the star is a variable of the well-known type in which the hydrogen lines are bright at the time of maximum, rather than a *Nova;* but some spectra of well-known variables of the type referred to will be photographed with the same instrument for purposes of comparison. C. D. P.

May 21, 1903.

A NEW STAR IN *GEMINI.*

A telegram received at the Lick Observatory on March 27th announced the discovery at Oxford, England, of a new star in the constellation *Gemini.*

Cloudy weather prevented observations here until the night of April 1st, when the star was found to be of about 8.5 magnitude. Notes on the photographic and spectrographic observations will be found on another page. In addition to these, micrometric measures were made connecting the *Nova* with five faint stars that are well placed for detecting any parallactic or proper motion it may have. It was the intention also to watch the brightness of the *Nova* closely, to see whether its light fluctuated as did that of *Nova Persei.* But cloudy weather interfered so much with this part of the program that no conclusions can be drawn from the observations. The star has gradually faded, however, and is now about 10th magnitude. R. G. AITKEN.

May 21, 1903.

OBSERVATIONS OF *NOVA GEMINORUM* MADE WITH THE CROSSLEY REFLECTOR.*

Stormy weather prevented any observation of Turner's *Nova* until April 1st. On this date a photograph of the region was secured with an exposure of $1^h\ 46^m$, as well as a number of short exposures. No traces of any nebulosity were to be seen about the star, as in the case of *Nova Persei.* This result was not surprising, considering that in all probability the magnitude of the outburst was much less. These plates showed that *Nova Geminorum* was considerably brighter photographically than visually, notwithstanding its reddish color. At this time it was estimated as of 8½ visual magnitude. Short-exposure photographs were obtained on several succeeding nights for measurement.

The position of the *Nova,* as derived from two of these plates, using six catalogue stars, is as follows:—

1903.		R. A., 1903.0	Decl., 1903.0
April 1.	Plate No. 1298............	$6^h\ 38^m\ 0^s.50$	$+\ 30^\circ\ 2'\ 28''.7$
5.	" 1309............	0.47	28 .7

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* Abstract of L. O. Bulletin, No. 37.

A number of the faint stars near the *Nova* were measured, and their positions follow:—

		Date, April 5. Plate No. 1310.		Date, April 8. Plate No. 1316.	
Star.	Magnitude.	p	s	p	s
		°	"	°	"
a	10	0.53	369.80	0.53	369.80
b	13	17.30	103.01	16.95	102.93
c	9.5	59.88	585.50	59.95	585.51
d	14	104.78	32.01	105.05	32.00
e	11	114.05	334 80	114 03	334 72
f	15	170.60	45.34	169.82	45.51
g	14	196.67	85.04	196.55	84.84
h	11	219.08	434.06	219.10	433.77
i	10	261.62	316.68	261.68	316.56
j	9 4	276.57	465.23	276.58	465.14
k	13	314.05	100.16	313.88	100 27

Star *j* is B. D. + 30° 1309.

The spectrum was photographed with the slitless spectrograph, with varying exposures and on several nights. The negatives show the usual bright lines which have been observed in other new stars in their early history, together with considerable continuous spectrum.

The following lines were measured on a plate taken on April 2, 1903:—

λ 486	$H\beta$	Bright.
462		Very bright.
446		Faint.
434	$H\gamma$	Very bright.
410	$H\delta$	" "
397	$H\epsilon$	Bright.
389	$H\zeta$	Faint.
384	$H\eta$	Maximum.
374	$H\kappa$	"
350		"
335		End of spectrum.

The positions 384, 374, and 350 are the maximum of what appear to be bands with this low dispersion. The maxima at λ374 and λ350 are near the positions of two very bright lines in *Nova Persei,* which were observed by Dr. STEBBINS after the spectrum of that star had become nebular. Two lines at about the same wave-lengths were discovered in some of the well-known nebulæ by Dr. PALMER. In *Nova Geminorum* these lines are not yet developed, and are relatively very much weaker than they were in *Nova Persei*. As there are no early observations of this portion of the spectrum of *Nova Persei*, it is not possible to draw any conclusions as to these lines. It seems reasonable to expect, however, that they will develop along with the other nebular lines. C. D. PERRINE.

THE SPECTRUM OF *NOVA GEMINORUM*.

The spectrum of *Nova Geminorum* was observed, both visually and photographically at the Lick Observatory, with a spectroscope consisting of a single flint-prism mounted in conjunction with the collimator and camera of the regular Mills spectrograph. Unfortunately, unfavorable weather prevented any observations before April 1st, but after that date spectrograms were obtained on several evenings, both in the blue-violet region, and, by the use of isochromatic plates, in the visual part of the spectrum. The spectrum consists of broad, bright bands with some continuous spectrum. In its general features it resembles somewhat the spectrum of *Nova Persei* in March 1901, and also that in August of the following year; probably the star at its discovery had reached a stage in its development midway between those of *Nova Persei* at these two dates. Many of the bands coincide approximately with the lines of the hydrogen spectrum, and though a number of them could not be identified with hydrogen-lines, there was no certain trace of the so-called "nebular-lines," except the principal line λ 5007.

Between the date of the first spectrogram, April 2d, and that of the last, May 4th, the spectrum showed definite changes, but they are of such a nature that it cannot be said whether or not they indicate a progression toward the nebular type.

H. M. REESE.
H. D. CURTIS.

NOVA GEMINORUM.

The first opportunity of obtaining a long exposure on *Nova Geminorum* with the Crossley reflector, occurred on April 22d, 23d, and 24th, when a duration of 6^h 29^m was secured.

There are no indications of nebulosity about the *Nova* on this plate.

The spectrum was last photographed with the slitless spectrograph on May 11th. The star has faded nearly a magnitude in the interval, and the entire spectrum is weaker in consequence. There is a slight strengthening at about the position of the chief nebular line, and the bands at λ 373 and λ 350 seem to be slightly stronger. C. D. P.

May 21, 1903.

Two New Naked-eye Double Stars.

The brighter stars of the northern heavens have been examined so many times with telescopes of all sizes that one hardly expects to find among them a double star that has not been observed before. Two such stars, however, belonging to two very different classes of double stars, have apparently hitherto eluded detection. The first is a star in *Coma Berenices*, rated at 6.0 magnitude in the Bonn D. M. On April 8, 1903, I examined this star with the 12-inch telescope and found that it was attended by a 12th-magnitude companion. One night's measure with the 36-inch telescope gives the position-angle 259°.7 and the distance 1″.35. As the principal star has an annual proper motion of 0″.22 in 148°.5, both the angle and distance should increase if the two stars are not physically connected.

The other star is in the constellation *Boötis*, not far from *Arcturus*, and is given as 5.9 magnitude in the Harvard Photometry. With the 12-inch telescope, on May 5, 1903, this star was seen to be a very close double. Measures on two nights with the 36-inch give: position-angle, 199°.8; distance, 0″.20; magnitudes, 6.5–6.5. The star has no proper motion.

The positions of these two stars for 1900.0 are, respectively: R. A., $13^h\ 28^m\ 4^s$; Decl., + 24° 52′; and R. A., $14^h\ 27^m\ 55^s$; Decl., + 27° 7′. R. G. Aitken.

May 12, 1903.

Correction to the American Ephemeris for 1903.

In observing the satellites of *Uranus*, it has been my practice to guard against mistaking a small star for a satellite by computing the approximate positions of the satellites for the time of observation from the times of greatest elongation and position-angle of the apparent apsides as given in the American Ephemeris. Until this year the agreement with observation has always been close—1° or 2°. But this year my observed angles are invariably *90° smaller* than the computed ones. It would seem, therefore, that the times of greatest elongation as given in the American Ephemeris for 1903 are systematically in error by one fourth of the periods of the satellites.

R. G. AITKEN.

COMET *b*, 1903.

A telegram from Boston was received at the Lick Observatory on the evening of May 2d, announcing that a comet had been discovered by GRIGG at Thames, New Zealand, on April 17th, and had been observed by TEBBUTT at Windsor, N. S. W., on April 26th. The comet was looked for here on the evenings of May 3d and 4th, but it was so near the horizon at sunset that it could not be seen. A telegram giving elements and ephemeris of the comet was received on May 7th. From these it appears that the comet is moving east and south and is rapidly growing fainter. It is not likely to be visible at all from northern observatories.

It will be seen that nine days elapsed between the time of the comet's discovery and the date of the first accurate observation, and six more days were needed to get the news to northern observatories. These were unfortunate delays, though presumably unavoidable. Had news of the discovery reached us promptly some observations of the comet could have been secured here.

R. G. AITKEN.

May 14, 1903.

REPORTS OF OBSERVATORIES.

THE LAWS OBSERVATORY OF THE UNIVERSITY OF MISSOURI, COLUMBIA, MISSOURI.

The work of the Department of Astronomy of the University of Missouri consists of instruction in the various branches of the science as presented to the students of the University, and in the prosecution of such observations as can be made satisfactorily with the equipment of the Laws Observatory.

The principal instrument of the observatory is a 7½-inch equatorial, constructed by Merz & Sons about 1848. The objective is of fair quality, although the glass entering into it is somewhat defective. The mounting is of the original Fraunhofer design, with the slight modification introduced by Merz, and, though inconvenient, and in some respects defective, the instrument is, nevertheless, serviceable for many kinds of observations. The driving-clock, fitted with a Fraunhofer governor, is of the type found upon all the Munich instruments of that period. Until recently the telescope has been supported by a wooden framework which stood upon a brick pier terminating two feet below the floor of the equatorial-room. The wooden support has been replaced by a cast-iron column, which gives the instrument a thoroughly stable foundation. The lower sections of the column were obtained from Warner & Swasey, and are a part of their standard 8-inch equatorial mounting. The pier-head casting was constructed from designs and patterns made in the shops of the University. The instrument is fitted with a micrometer of the Fraunhofer type and with an excellent modern micrometer by Saegmuller.

The telescope is, in a sense, an historic instrument, as will be seen from the following extract from the University of Missouri Catalogue for 1884-1885:—

> "This telescope was ordered in 1848 from the establishment of Merz & Mahler,* of Munich, for the use of Shelby College, Shelbyville, Kentucky. It was received at Shelbyville in November, 1850, and cost, when mounted, $4,000. It was mounted under the direction of Prof. Joseph Winlock, and used by him while he was a professor in that institution. After Prof. Winlock went to Cam-

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* The telescope bears the inscription: Merz u. Söhne in München.

bridge, Mass., he borrowed this telescope, and, in connection with Dr. B. A. GOULD, established there the Cloverdon Observatory. In LOOMIS's *Recent Progress of Astronomy*, the following statement is made respecting this instrument, which was then the fourth in magnitude in the United States:—

"'The great telescope belonging to Shelby College was loaned to Prof. JOSEPH WINLOCK, and was removed to Cambridge, Massachusetts, where temporary accommodations were provided for it, and this establishment is known by the name of Cloverdon Observatory.' . . . 'Numerous observations on comets, and on some of the newly-discovered planets, have been made with this telescope by Dr. B. A. GOULD and Prof. JOSEPH WINLOCK, some of which have been published in *Gould's Astronomical Journal.* This great telescope has recently been returned to Shelby College.'

"In 1869 Prof. WINLOCK, who was then Director of the Observatory of Harvard College, went with his assistants to Shelbyville, Kentucky, and there used this telescope in observing the total eclipse of the Sun, which occurred on the 7th of August of that year."

During the past year considerable additions to the equipment of the observatory have been made through various purchases. A Pickering stellar photometer by the Alvan Clark & Sons Corporation, and a disk photometer by Brashear have been obtained. The latter is to be used for testing purposes; the former, for systematic observations of variable stars. The Observatory has been re-wired for electrical connections, and a new and simplified switch-board has been introduced. Considerable quantities of minor apparatus, such as sextants, artificial horizons, testing instruments, batteries, etc., have also been acquired.

Since September, 1901, the time has been occupied mostly in a reorganization of the observatory and in the accomplishment of certain administrative details. The library has been increased through gift by about 600 books and pamphlets, and, through purchase, by seventy-seven volumes.

Since September, 1902, 53 observations of comets have been made. Of this number, 32 were of Comet *b* 1902, 5 were of Comet *d* 1902, and 16 of Comet *a* 1903. Thirty of the observations of Comet *b* 1902, together with an orbit based upon intervals of 26 and 28 days, have been published and distributed in Laws Observatory Bulletin No. 1.

F. H. SEARES,
Professor of Astronomy and Director of the Laws Observatory.

ALLEGHENY OBSERVATORY.

The present staff of the Observatory is constituted as follows: F. L. O. WADSWORTH, Director; FRANK K. BAILEY, Assistant; ALICE E. DAVIS, Secretary and Assistant. At present Mr. BAILEY'S time is devoted almost exclusively to the maintenance of the time service; Miss DAVIS has been engaged in library and general correspondence work, and has also rendered very efficient service as a computer.

The new observatory building still remains unfinished, and a considerable part of the coming year must elapse before the books and instruments can be transferred to it from our present site.

Very little progress has likewise been made in getting ready the equipment of the new building. The only points of interest in this connection are the following:—

(1) The disks of the 30-inch refractor, which were ordered of Mantois in June, 1899, were received from him on February 19th of the present year. Both disks are beautifully clear and transparent, and, as far as can be determined by preliminary tests, of first-class optical quality. The constants of both the flint and crown glass have been accurately determined and carefully studied by Professor HASTINGS, who has submitted several alternative designs of optical construction. The final type has not, however, been definitely decided upon.

(2) *The Westinghouse Electrical Equipment.*—After careful consideration of the plans of electrical equipment and proposed research work of the electrical laboratories, Mr. WESTINGHOUSE most kindly and generously volunteered to practically double the amount of his original gift, in order to more fully provide for these purposes. As now provided, the generating plant will consist of two 37½-kilowatt dynamos, directly connected each with a 50 H. P. triple cylinder Westinghouse gas-engine. The dynamos will be specially built to give either direct or alternating currents. As D. C. machines they can be connected in multiple to give a current of 600 amperes at 125 volts, or in series to give a current of 300 amperes at 250 volts. As alternators they will furnish a corresponding current at a mean E. M. F. of 90 volts and 1,800 cycles per minute, which can be transformed by step-up transformers to any voltage desired for induction coil and high potential spark

discharge work, or by step-down transformers to furnish a low voltage current of several thousand amperes for electric furnace work. In this experimental work the low rate of alternation, while unsuitable for electric lighting, is in many cases a decided advantage.

In addition to these generators, the plant will also contain a rotary transformer of 5 K. W. capacity, which can be used to give alternating currents of a higher rate of frequency, *i. e.* 7,200 cycles per minute, if desired. This can be driven either directly from one of the main generators or from a storage battery. The final plans contemplate the installation of a storage battery of at least 100-kilowatt hours capacity, so that using both generators and storage battery in multiple, currents of at least 1,000 amperes at 100 volts, or 10,000 amperes at 10 volts, may be obtained for short intervals for experimental work. At present, however, this storage battery is not provided for.

With the generous assistance and active co-operation of two of the members of our Visiting Committee, funds were secured for the erection of the power-house during the latter part of the year. The building, which has been erected by Beunte & Martin, is now nearing completion. It is entirely of concrete, with Berea stone facings similar in general design to the main observatory building. At present only one story has been erected, the roof, which is flat and of heavy concrete construction, being on a level with the ground about the main building. The northern front faces on the proposed park road, and a flight of stone steps of plain but handsome design leads from the lower terrace level, along which the road runs, to the upper terrace level about the main building.

(3) The construction of the new clocks for the Observatory has been intentionally postponed until some experiments now in progress elsewhere have been completed, and until the new building is ready for their reception. There is no place at the present observatory where further experimental work on the various questions connected with the final design of these clocks can be advantageously carried on, and no place where they could be installed even if finished.

(4) The contract for the Keeler Memorial Telescope, both optical parts and mountings, was let to the John A. Brashear Company, January 24, 1902. The disks for the 30-inch specu-

lum and the 18-inch and 12-inch flats for the attached cœlostat and polar heliostat were received on March 26th, and have been roughed out and fined ready for the final polishing and figuring. The two observing floors for the instrument have been erected and the heavy cast-iron piers delivered at the observatory, but have not yet been placed in position. I regret to report that very little work has been done on the mounting itself, but this is now being pushed more rapidly.

(5) The principal optical parts of the Porter 10-inch grating spectroscope have been begun, but no work has been done on the mounting.

(6) The two small domes have been erected and wood-sheathed, but not yet covered with metal. The form of running gear originally designed for these domes was changed by the Observatory Committee after the contract for the steel work was let. This change in the former involved other changes in the latter, which have somewhat delayed the construction and erection of the domes, and which have prevented the carrying out of certain special features of the control and operation of the smaller dome that from the standpoint of the astronomer seemed most desirable. This is to be regretted, as experience has conclusively shown that convenience and ease of operation of the instrument and its accessories is a prime requisite to efficiency in modern observational work of a spectroscopic and astrophotographic character.

No changes have been made in the present observatory building or its equipment during the past year. As has already been stated, it is unsuitable for any experimental or observational work. Even the rooms used for offices and library are becoming unsuitable for further occupancy.

GENERAL NOTES.

WILLIAM HARKNESS.— For the following account of the late Professor HARKNESS we are indebted to one of his lifelong friends and colleagues:—

WILLIAM, son of JAMES and JANE (WEILD) HARKNESS, was born at Ecclefechan, Scotland, December 17, 1837. His parents were natives of Scotland, and came to New York in May, 1839. The father was a Presbyterian clergyman and also a physician of the homeopathic school.

During his boyhood WILLIAM lived in New York City and in Fishkill, N. Y., and attended the Chelsea Collegiate Institute in New York, and private schools in Fishkill Landing and Newburgh, N. Y. He entered Lafayette College in 1854, but, owing to the removal of his parents to Rochester, N. Y., he became a student in Rochester University in 1856, graduating there with the degree of A. B. in 1858. From Rochester he received the degree of A. M. in 1861, and that of LL.D. in 1874. From Lafayette he received the honorary degree of A. M. in 1865. He was a reporter in the New York Legislature in 1858 for the *Albany Atlas and Argus;* and in the Pennsylvania Senate, in 1860, for the *Harrisburg Daily Telegraph.* The skill acquired in this work as a stenographer was of great service to him throughout his active life. He studied medicine and graduated from the New York Homeopathic Medical College, receiving the degree of M. D. in 1862.

On August 1, 1862, he was appointed an "aid" at the United States Naval Observatory. After the second battle of Bull Run, August 30, 1862, he volunteered as a medical man to assist in the relief of the wounded.

On August 24, 1863, he was appointed a Professor of Mathematics in the United States Navy, with the relative rank of Lieutenant-Commander, to fill a vacancy caused by the death of Prof. JOSEPH HUBBARD. During EARLY'S attack on Washington, July 11-12, 1864, he served as a volunteer surgeon.

From October 17, 1865, to June 28, 1866, he was attached to the United States monitor *Monadnock* for the purpose of observing the behavior of her compasses under the influence of the heavy iron armor of the vessel. During this period the *Monadnock* made the trip from Philadelphia around Cape Horn to San Francisco, and Professor HARKNESS made observations to determine the terrestrial magnetic declination, inclination, and horizontal force at the principal posts on the route. The observations and the discussion of the results were published by the Smithsonian Institution in 1871, a quarto volume of 225 pages, under the title, "Observations on Terrestrial Magnetism and on the Deviation of the Compasses of the United States iron-clad *Monadnock* during her cruise from Philadelphia to San Francisco in 1865 and 1866, by WILLIAM HARKNESS, M. D."

On returning to Washington he was attached to the Hydrographic Office from October 14, 1866, to October 1, 1867, and to the Naval Observatory from October 1, 1867, to May 30, 1874.

On August 7, 1869, he observed the total solar eclipse at Des Moines, Iowa, and at that time discovered the now well-known Coronal line K 1474.

On December 22, 1870, he observed the total solar eclipse at Syracuse, Sicily, and early in 1871 visited several of the principal observatories in Europe.

On November 13, 1871, he was appointed one of the original members of the Transit of *Venus* Commission, and was principally employed with other members of the Commission in arranging for the observations of the transits of December 9, 1874, and of December 6, 1882. From November, 1871, to the time of his detachment from the Observatory in 1874, he did but little observing but devoted most of his time to work of the Transit of *Venus* Commission. Professor HARKNESS was formally detached from the Observatory on May 29, 1874, and did not resume his connection with astronomical work at the Observatory for twenty years.

He was in charge of the Transit of *Venus* party at Hobart, Tasmania, where the weather on December 9, 1874, was favorable for good observations. On June 22, 1875, he was ordered to the Observatory for service with the Transit of *Venus* Commission in connection with the reduction of the observations by the different observing parties.

For the purpose of utilizing the photographs taken by these parties Professor HARKNESS devised a measuring engine for determining with sufficient accuracy the relative positions, on the plate, of the centers of the Sun and *Venus*. About this time he designed an attachment to a spherometer caliper for measuring the figure of pivots of astronomical instruments.

He observed the Transit of *Mercury* on May 6, 1878, at Austin, Texas; and the total solar eclipse of July 29, 1878, at Creston, Wyoming. He also edited the volume containing the reports of the observations of the 1878 eclipse. In 1880 and 1881 the photographic observations of the Transit of *Mercury* were reduced under his supervision.

About this time he was engaged with others in making experiments to determine the best form of apparatus for photographing the solar corona during total eclipses.

In 1881-83 he did some work on the reduction of GILLISS's Zones, observed at Santiago, Chile, in 1849-52.

For some time previous to 1882 he was employed, under the direction of the Transit of *Venus* Commission, in making preparations for observing the transit of *Venus* on December 6th of that year. He observed the transit of *Venus* from the grounds of the Naval Observatory in Washington and was afterwards assigned to the duty of reducing all the observations made by the parties organized under the Transit of *Venus* Commission. In about six years the result from the photographic observations was reached and a brief statement was published in a report to the Secretary of the Navy.

From 1888 to 1891 he was principally occupied with his work on "The Solar Parallax and its Related Constants," which was printed in 1891. From 1891 to 1894 he was engaged in miscellaneous work, some of it relating to the building of the new Naval Observatory and the construction of some of the new instruments.

On October 21, 1892, he was appointed chief astronomical assistant to the Superintendent of the Naval Observatory and on September 21, 1894, he was appointed Astronomical Director of the Observatory with general supervision of all the astronomical work. On June 30, 1897, he was appointed Director of the American Ephemeries and Nautical Almanac, and he retained both these offices until his retirement for age, December 17, 1899, with the rank of Rear-Admiral.

Professor HARKNESS published many scientific papers and was a member of a number of scientific societies.

He was a founder and at one time President of the Cosmos Club in Washington, a President of the Philosophical Society of Washington, Vice-President of the American Association for the Advancement of Science in 1881 and 1885, and President of the same society in 1893.

His principal public addresses were:—

Vice-Presidential address before Section A, American Association for the Advancement of Science, on "Transits of *Venus*";

Presidential address in 1887 before the Philosophical Society of Washington, on "The Progress of Science as Exemplified in the Art of Weighing and Measuring";

Presidential address in 1894 before the American Association for the Advancement of Science, on "The Magnitude of the Solar System."

During Professor HARKNESS's service at the Naval Observatory, from 1862 to 1874, he worked as an observer with the Prime Vertical Transit, the Mural Circle and the Transit Circle. He had charge of the latter instrument from January 1, 1870, to May 29, 1874. As an observer, he was methodical, painstaking, and especially careful in regard to the most minute details. A duly formulated regulation always received his profound respect.

Soon after 1871 his health seemed to demand special care, and from that time until his detachment in 1894 he did very little observing.

His principal work from 1874 to 1894 was with the Transit of *Venus* Commission and after the transit of 1882 he had charge of all the reductions. The general government spent large sums of money in fitting out the various observing parties in 1874 and 1882 and many thousands of dollars in measuring the photographic plates and in making the necessary reductions. Much interest was felt among astronomers in regard to the deduced value of the solar parallax and the Commission authorized and urged a speedy reduction of the work. In 1889 a brief report, announcing the value of the solar parallax as found from the measures of the photographic plates, was printed but no further progress has been made. The value of the parallax from the telescopic observations of the four contacts has not been computed nor have the reports of the observers been printed.

For many years much dissatisfaction had existed among the astronomers of the country with the management of the Naval Observatory, the only government institution of its kind. Many efforts had been made to secure a competent astronomer for superintendent but without success.

Soon after the observatory was moved to Georgetown Heights the pressure from astronomers outside of Washington became so great that it was deemed politic to make an apparent concession to the demand, and the position of Astronomical Director was created by order of the Secretary of the Navy. By the terms of that order the entire astronomical work of the observatory was placed under the supervision of the Director, but he had no adequate control of the personnel. In reality the order bestowed the maximum of responsibility and the minimum of power.

The selection of the proper person for Director was not an easy task. To many of the available officers it was a very undesirable berth. Finally it was accepted by Professor HARKNESS, against the advice of friends, and he assumed the duties with the firm belief that the complete success of the new departure was assured.

To that end he labored with great zeal, devoting his whole time and strength to the cause.

The magnitude of the undertaking and its probable failure were soon apparent, but to the day of his retirement he worked and hoped for ultimate success.

After he left the Observatory the office was continued but a little more than a year.

The work of Astronomical Director and as Director of the Nautical Almanac had already begun to affect seriously his constitution and when, in January, 1900, he attempted to take up again some portions of the unfinished Transit of *Venus* work he was unable to recognize the meaning of the formulæ with which he had been so familiar but five years before. Attributing this failure to nervous prostration he went to his home in Jersey City where he hoped that a few weeks of rest would completely restore his health. There his condition changed but little until February, 1903.

Occasionally some slight improvement would occur but it would be of short duration, and he was unable to do any mental work beyond writing a short letter.

On February 18th it was manifest that Bright's disease had developed. Its progress was rapid; and, happily forgetting his worries and struggles, he passed on peacefully on the afternoon of February 28, 1903.

Spiral Nebulæ.—Sir ROBERT BALL in his lectures on "Astronomical Problems," in London recently, drew attention to the spiral form of many of the great nebulæ. Professor KEELER, he remarked, had during his lifetime attempted to make a chart of the sky by means of photographs taken with the great Crossley reflector at the Lick Observatory. For this purpose he divided the sky into sections, and had intended to photograph each in turn. This task he did not accomplish; but whereas before his investigation began the number of known nebulæ was about 8,000, his investigation left this number multiplied to at least 120,000. Now, there were nebulæ and nebulæ; they differed as one star differs from another in glory; their variety was infinite. They might be divided into young nebulæ and adult nebulæ. Professor KEELER found that half the nebulæ of the sky were spiral nebulæ, and presented us with the astonishing fact that next to a fixed star the spiral nebula was the most characteristic object of the sky. The spiral nebula was to be regarded as an adult nebula, because Sir WILLIAM HUGGINS's beautiful spectroscopic method revealed to us that its spectrum was a continuous spectrum, and that therefore the nebula was no longer a mere chaos of incandescent gas, but had begun to condense down into something more approaching substance. The evolution of the chaos of gas into a spiral proceeded solely from the mutual action of its parts.

ANDREW GREIG.

Source of the Sun's Heat.—In another lecture Sir ROBERT BALL considered the sources of the heat of the Sun. He reviewed the theory of HELMHOLTZ. According to this theory, the Sun is shrinking. It shrinks sixteen inches in diameter daily; it has been shrinking daily ever since it was a great gaseous nebula, extending over a millionfold greater extent of space. Now, the molecules of a body—we may, for clearness, think of a gaseous body and of the molecules of a gas—are in constant vibration while the body is radiating heat. If heat is added to the body, the rapidity of the motion of the molecules increases. Conversely, if the rapidity of the movement of the molecules increases, more heat is given out. The falling in of the Sun's circumference due to the sixteen inches of daily shrinking gives these molecules some distance to fall. It is not a great distance, but there are a great many molecules. Their motion is increased by their daily drop of sixteen inches. Consequently, this addition to their velocity adds to their heat, and thus by the Sun's shrinking the supply of radiated heat is lifted towards the level of the expenditure. But the lecturer proceeded to show that this is not a complete or a completely satisfactory explanation. We may take it that in shrinking from its nebulous form down to its present dimensions the Sun has given out heat equivalent to about 3,400 times its own mass in coal. Each coal unit would have lasted the Sun 2,800 years. If we continue this calculation, and seek to find the number of coal units that the Sun will have consumed between the time it was a gaseous nebula and the time when it shall become a solid body as dense as the densest substance known,—platinum,—we find that it will have consumed 8,300 coal units. In other words, roughly speaking, 24,000,000 years will have elapsed. But 24,000,000 years between the Sun's gaseous nebulous state and the state in which it will become at least as cold as the Earth is now, and cease practically to give out heat at all, is not enough. We know by various considerations that this estimate is too small, and therefore there must be other possible sources of the Sun's heat. What other sources were there? The fall of meteors into the Sun had been suggested; but it was shown by a simple calculation that the quantity of meteors, traveling at 400 miles a second, which would have to fall into the Sun each day to keep up its heat would have to be equivalent in mass to the Moon.

Finally, Professor BALL considered another point. The Earth received heat from the Sun, but the Sun was radiating heat everywhere. If a spectator on the Sun compared the space in the heavens occupied by the Earth with that occupied by the Great Nebula in *Orion*, he would find that the Earth occupied only one two-hundred-thousandth part as much space as the *Orion* nebula. Therefore, we had this fact, that the Great Nebula in *Orion*, though it was a million times farther from the Sun than we were, was receiving 200,000 times as much heat a day. Now, there were visible to our telescopes perhaps about 120,000 nebulæ—all giving out heat, as the Sun had been for ages giving out heat, and all of them sending out heat in all directions. If the nebulæ of the sky had all received heat from the Sun, then—and here was the point—the solar nebula had received heat from the stars in its turn.

ANDREW GREIG.

The Age of the Sun.—Sir ROBERT BALL in his concluding lecture at the Royal Institution, London, dealt with the problem of the age of the Sun, if it were assumed that the Sun and its planets had been evolved from a nebula. He showed the mathematical reasoning by which it is proved that no ray of the Sun can ever escape to infinity. If we supposed the universe to be split up into cubes with sides a billion miles long, a billion miles being the distance of the nearest fixed star, and if at the corner of each of these cubes were placed something no larger than a molecule, no larger even than an "electron," then all the rays of the Sun would be stopped within a finite distance. It would require the universe to be peopled with matter no more thickly than an electron to a billion cubic miles to capture every ray. Now, let the Great Nebula in *Orion* be considered. That nebula caught and stopped one ten-thousandth part of the rays of the Sun; and if the stars above the tenth magnitude be reckoned at 600,000, then *Orion* might be regarded as stopping the whole light of sixty stars during the whole of its life as a nebula. The energy thus received would immensely add to its own energy. Similarly, the rays of energy which the Sun, once a nebula perhaps not much less in size than the great Dumb-bell Nebula, had received must have greatly prolonged its life as a nebula. The 24,000,000 years which were all that could be allowed it, had it received no energy from outside, must have been increased to a higher order of number altogether. Professor BALL did not hesitate to write the figure as a hundred million years, and that, he hinted, he regarded as much too small for the age of the Sun. ANDREW GREIG.

The South Polar Cap of Mars.—In the May number of the *Astrophysical Journal,* Professor E. E. BARNARD gives some account of his observations of the South Polar Cap of *Mars,* made at the Lick Observatory during the oppositions of 1892 and 1894. In addition to the usual drawings of the planet, Professor BARNARD made careful micrometer measures of the diameter of the Polar Cap throughout both oppositions,—a practice that is heartily to be commended in the study of all planetary markings. Recently Professor BARNARD reduced these measures to the mean distance of *Mars,* and then drew curves, using the measured diameters of the Polar Cap as ordinates, and the days before or after the summer solstice for the southern hemisphere of *Mars* as abscissas. Two facts of great interest are at once evident from these two curves: (1) they are parallel throughout, showing that the cap at both oppositions followed with surprising closeness the same law of decrease; and (2) the cap continues to decrease for a month or more after the summer solstice, indicating that on *Mars,* as on the Earth, the time of highest temperature is not reached until several months after the maximum of solar heat.

Professor BARNARD seems to incline to the early view that the Polar Caps on *Mars* are due to accumulations of snow, saying that this is as good a theory as any of those put forward to-day to explain the phenomenon.

At the last annual general meeting of the Royal Astronomical Society the society's gold medal was awarded to Professor HERMANN STRUVE, Director of the Königsberg Observatory, for his work on the satellites of *Saturn.*

Dr. FRANK SCHLESINGER resigned his position as observer in charge of the International Latitude Station at Ukiah, Cal., on May 1st, 1903, to accept a position at the Yerkes Observatory. Dr. S. D. TOWNLEY is Dr. SCHLESINGER'S successor at Ukiah.

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NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

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SUGGESTIONS CONCERNING FUTURE OBSERVATIONS OF THE SATELLITES OF *URANUS*.

BY PROFESSOR HERMANN STRUVE.

The Tables of the Satellites of *Uranus*, published by Professor NEWCOMB in the "Washington Observations, 1873," can, by small changes of the mean motions, be brought in tolerable agreement with modern observations. Therefore, if we content ourselves with an approximate representation of the motions of the satellites, and if we make abstraction of the changes produced by the inclinations of the orbits, by their eccentricities, the secular motions and the reciprocal perturbations of the satellites, the tables mentioned will probably be sufficient for a long time. Future observations will then only contribute to a more exact knowledge of the mean motions of the satellites and of the mass of the planet. However, particular interest is connected with the small changes mentioned, especially as we may get thereby an answer to different questions concerning our knowledge of the planet, and as we may arrive at further conclusions by comparison with other systems of satellites.

By reason of the extreme faintness of the satellites, particularly of the two inner ones, such observations can only be made with some hope of success by the most powerful instruments. Also, the southern position of the planet during the next two decades forces us to exclude the participation of the more northern observatories. But on account of the numerous great refractors which at present are at the disposition of American observatories it may be expected that the observations necessary for the researches mentioned may be procured in the near future. With this view I beg leave to submit the following suggestions.

The observations made until now have proved that the satellites of *Uranus* move approximately in one and the same plane, not changing during a considerable space of time. Supposing, then, that in analogy with other planets *Uranus* has a sensible ellipticity, and neglecting the small masses of the satellites and the inconsiderable, in this system hardly perceptible, action of the Sun, it is evident that the orbits of the satellites form only small angles with the equator of the planet. For the secular motions of the satellites only some maximum values may be fixed at present, as the ellipticity of the planet is not yet determined by accurate observations. Assuming the greatest possible value of the ellipticity $\frac{a-b}{a} = 0.1$ and the major semi-axis of the planet $a = 1''.9$, the homogeneity of the planet would lead to the following values of the yearly motion of the apsides and of the nodes:—

$$\Delta\pi = -\Delta\Theta$$

Ariel,	55°. 2
Umbriel,	17 . 7
Titania,	3 .14
Oberon,	1 .13

Then, again, supposing the relations similar to those of *Jupiter* and *Saturn,* the values mentioned ought to be diminished to their half. It is to be remarked that, accepting $\frac{a-b}{a} = \frac{1}{14}$ and the time of revolution of the planet in round numbers equal to ten hours, as with *Jupiter* and *Saturn,* we shall find nearly the same value for the well-known constant of ellipticity: $\frac{\kappa}{a^2} = \chi - \phi/2$ as with those two great planets. Of course these numbers represent only an approximate estimate of the amount of the secular motion produced by the ellipticity. The motions produced by the satellites are even less sensible, if their masses are of the same order as those of the interior satellites of *Saturn.* Considering now that the observations of the satellites *Oberon* and *Titania* present only very small deviations from circular orbits, it is evident that only by observations of the two interior satellites, *Ariel* and *Umbriel*, the eccentricities and inclinations of which may be equal to 0.02 and 1° or 2°, respectively, can a solution of the problem to determine the motions mentioned be expected in a comparatively short time.

For the observation of those two satellites it may be particularly recommended to join both with *Titania*, whose orbit apparently offers the smallest eccentricity, by measures of position-angle and distance. The direct junction of the small satellites with the center of the planet, using bright micrometer-wires, is exposed to the objection that the pointing of the satellites will be different from the pointing of the limb of the planet, on which the wire appears as a dark line. From this circumstance considerable errors depending also on the position-angle might be produced. Also the junction of the interior satellites with *Titania* will no doubt be more exact. Such measures being made during one and the same opposition in sufficient number, and being continued in the same way through several oppositions, the elements of the planes of *Ariel* and *Umbriel* (γ, θ) with their yearly changes will be found nearly independent of the supposed elements of *Titania*. The elliptic elements (e, π) can not be deduced with the same accuracy and independent of the corresponding elements of *Titania*, but even in this case we may expect to ascertain the deviation from the circular orbit, particularly as the lines of the apsides of *Ariel* and *Umbriel* will probably show considerable motion in a few years.

Similarly, the determination of the elements of the planes (γ, θ) of *Oberon* and *Titania* will be most favorably obtained by the junction of these two satellites with each other. But the deviation from the circular orbit (e, π) being very small for both satellites, will result with only small weight. To determine this it is more profitable to join these satellites directly to the planet. As it appears not quite impossible that by the most powerful instruments we might see *Oberon* and *Titania* in the feebly illuminated field, the joining of the two satellites with the limbs of the planet by rectangular coordinates x, y might be recommended. This method of measures has been executed by me several times for the satellites of *Mars* as well as of *Saturn*, with an accuracy which, some precautions being observed, will not be much inferior to the junction of the satellites with one another.

It appears that in general the elements e, π for the satellites of *Uranus* will be determined at other times than the elements γ, θ. At the present time, and during several years to come, when the orbits are wide open, we have the best opportunity for the determination of e, π, but there is no chance to determine γ, θ with more accuracy than it has already been done for *Oberon* and *Titania*. Not before ten or fifteen years will the elevation of the Earth above the orbits of the satellites diminish so far that we may proceed to a new determination of the planes and of their secular variations.

Of course, for the theory of the system of *Uranus* it would be most important to remove the uncertainty which still exists concerning the ellipticity of the planet. Also, in this regard an answer can be expected, particularly from the large refractors having the advantage of larger focal images than the smaller telescopes. In this connection attention may be called to the suggestion made by Professor Seeliger (*Sitsungsberichte München,* Band XIV) some twenty years ago: To examine by the help of prismatic eye-pieces in what degree the determination of the diameter may depend upon the direction to the horizon. Further, it appears to me that the atmospheric dispersion may be a source of error not yet sufficiently considered, by producing a different coloration of the borders of the planet which will interfere with the uniform pointing of the micrometer-wires on the planet's limbs. This source of error, which has proved to be very important in my measures of *Saturn,* being partly physiological, can affect in different manner the measures of different observers, and may perhaps explain the considerable differences of the various determinations of the ellipticity. When the elevation of the Earth over the planes of the satellites has diminished so far that the ellipticity may be determined anew,—that is, in about ten or fifteen years,—it will certainly be necessary to attempt the elimination of the source of error mentioned by the use of a prismatic eye-piece and by executing the measures in different hour-angles and directions.

Koenigsberg, May, 1903.

THE SPECTRUM OF *O CETI.**

By Joel Stebbins.

On account of the great instrumental power required for the observation of the spectra of faint objects, changes in the spectra of long-period variable stars have not been well studied. In fact, there is no star which undergoes a large variation in brightness whose spectrum has been systematically followed from maximum to minimum, or *vice versa.* It is proposed to give here the results of a study of the spectrum of o *Ceti,* or *Mira,* made, at the suggestion of Director Campbell, with the thirty-six-inch refractor of the Lick Observatory, from June, 1902, to January, 1903. During this period the star faded in brightness from 3.8 to 9.0 magnitude. The first photograph of the spectrum was obtained about three weeks after the predicted time of maximum, and a series of plates was secured, covering the interval to minimum. No negatives were obtained after the star had again begun to increase in brightness.

The most important articles concerning the spectrum of *Mira* are those of Vogel,† Sidgreaves,‡ and Campbell.¶ Neither Vogel nor Sidgreaves followed the star long enough to find much change in its spectrum, and Campbell's work was mainly in connection with observations of the star for radial velocity, with the Mills spectrograph.

The spectrograph used in my observations was the one employed by Messrs. Campbell and Wright in their work on *Nova Persei* [L. O. Bulletin No. 8], designated as "Spectrograph I." It is the regular Mills spectrograph converted into a one-prism instrument. It gives good definition, on the same photograph, of the region from λ 3700 to λ 5600. Although this dispersion is only about one fifth of that of the three-prism instrument, it is enough to yield a very fair determination of velocity.

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* Dissertation in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the University of California. (Abstract.)

† H. C. Vogel. Ueber das Spectrum von *Mira Ceti.* Sitzungsberichte der Berlin Acad., 1896, p. 143.

‡ Walter Sidgreaves. The Spectrum of *o Ceti* as Photographed at Stonyhurst College Observatory. *Mon. Not. Roy. Astr. Soc.*, Vol. 58, p. 344, April, 1898.

¶ W. W. Campbell. Note on the Spectrum of *o Ceti.* *Astrophysical Journal*, Vol. IX, p. 31, January, 1899.

When the seeing is good, an exposure of ten minutes will give a satisfactory negative of a star to which the Draper Catalogue assigns the photographic magnitude 5.0. If *o Ceti* were of about the tenth photographic magnitude at minimum, it would require, roughly, an exposure one hundred times as long as a fifth-magnitude star, or about sixteen hours. Some of the light being in bright lines, we should expect a still longer exposure to be necessary. This estimate agrees with my experience. About July 1, 1902, an hour's exposure, just before daylight, could be made on the star, and it was bright enough to photograph in that time. An exposure of six hours at the time of minimum, using the fastest photographic plate obtainable, was not sufficient to produce a measurable image, although much could be seen in a qualitative way. On January 5, 1903, the date of my last negative, an exposure of five hours, beginning soon after sunset, was possible. Early in March, 1903, the spectrum was again bright enough to record itself with a fairly short exposure; and, in the absence of the writer, Messrs. REESE and CURTIS were ready to make an attempt, but bad weather prevailed.

As is well known, *o Ceti* and the other long-period variables have absorption spectra of SECCHI's third type. Some observers have found the region from $H\gamma$ toward the red crossed by a series of dark bands, with edges sharp toward the violet, and they report that from $H\gamma$ to the ultra-violet the dark-line spectrum is very similar to that of the Sun. At first glance this seems to be verified by my plates, but a closer study shows the details to be very different.

In comparing the star spectrum with the solar spectrum, it was not found best simply to measure the plates and then look for coincidences in ROWLAND'S table. It is easy to find a line in the table which agrees in position with the one on the plate, but the intensities may be very different. The method adopted was to compare a plate of *o Ceti* with one of the sky. The two negatives, film sides together, were examined under the microscope with a low power.

The strong calcium lines *g*, *H*, and *K*, are present in the spectrum of the star, the *g* line being much more intense than in the solar spectrum. The strong iron lines of the Sun are not so prominent in *o Ceti*; in fact, they do not show with low dispersion. Of the large number of lines in the star spectrum, there are few which coincide with lines of like intensity in the solar spectrum.

The absorption spectrum of *Mira* was measured accurately on six plates. Each plate was measured and reduced independently, so that a faint line might be measured on one plate without being noticed on any of the others. This does not mean that it had developed, or that its intensity had changed. Such lines, of which many were measured, could be easily obscured by an irregular arrangement of the silver grains. The best method of verifying changes is to examine different plates simultaneously, in pairs, under the microscope. This has been done, and all changes in intensity or character have been noted.

About one hundred lines were measured in the region from λ 3900 to λ 4400. Residuals have been formed by subtracting the mean wave-length of each line from its measured wave-length on each plate.

The residuals for each plate have been averaged; and if there were any change in the velocity it would appear in the mean residuals. The arithmetical means of the residuals to the violet of λ 4400, and the corresponding velocities in kilometers per second, are as follows:—

Date.	Plate No.	tm.	km.
1902, July 6	7 C	+0.02	+1
16	13 E	+0.06	+4
Aug. 4	25 F	—0.03	—2
11	27 D	—0.02	—1
25	28 D	—0.03	—2
1901, Aug. 17	2235 D	+0.02	+1

When it is remembered that all lines, good and poor, were included in the means, and that these plates were taken with a one-prism instrument giving a dispersion of but one fifth of that of the regular Mills spectrograph, the range of only 6^{km} on six plates is very satisfactory. None of the plates taken later in 1902 are good enough to afford comparable conclusions as to the velocity; and it was thought best to measure only first-class plates in this connection.

The result that the star's velocity was constant over a certain period was derived without assuming the coincidence of any of the star lines with lines of the solar spectrum, or with other known lines. A determination of the actual radial velocity requires an assumption as to what the wave-lengths of the star lines would be if they were not affected by velocity. Agreements of star and solar lines were looked for, by direct comparison of the star plates with a solar plate, and only ten coincidences were found. Six of these lines were good enough to be used for determination of velocity, and they give $+66^{km}$.

CAMPBELL in 1898 found $+62^{km}$ with the three-prism instrument. The interval between August 29, 1898, the date of his first plate that year, to August 25, 1902, the date of my last plate which was measured, is equal to 130 days more than four periods of 331 days. The radial velocity has therefore been observed to be constant over about two fifths of the period of light change.

To determine more coincidences, I have measured one of the high-dispersion plates of o *Ceti*, taken by Dr. CAMPBELL in 1897. Although the plate is under-exposed, about seventy lines were measured between λ 4300 and λ 4420, and more than twenty coincidences were found by direct comparison with a solar plate. My measures of this plate give a velocity of $+63^{km}$.

A brief summary of the number of dark lines of different elements observed in the spectrum with both three- and one-prism instruments, may be of interest:—

Element.	No. of Lines.
Ca	6
Fe	11
Cr	9
V	11
Al	2
Sr	1
Mn	3 } ?
Ti	2 }

There can be no doubt of the presence of the first four elements in the list, and the aluminum and strontium lines are prominent; but manganese and titanium must be considered as doubtful.

On account of the varying instrumental conditions it is easy to fall into error in judging as to changes in the intensity and character of dark lines. If all the negatives were of the same density and of uniform excellence, it would be easy to note such changes. There is one dark line which showed changes of which the reality is certain. This is the *g* calcium line at λ 4227.84. Measures of its width are necessarily rough, and must depend much upon the judgment of the observer. The measures of two plates are as follows:—

Date.	Plate.	Width.
1902, June 27	2 B	2^{tm}
September 6	33 D	9

Other plates taken between these dates gave intermediate values.

The general impression formed from examining the series of plates is, that many other lines also grew broader as the brightness declined, but this is not certain. The effects of greater width of the slit, reduced intensity of the resulting negative, and flexure and temperature changes resulting from longer exposure, would all tend to make the lines wider and less sharply defined. The *H* and *K* lines are not shown on most of the plates, and nothing can be said as to changes in their character.

A few lines not visible on the early plates became prominent later. Lines of the solar spectrum which certainly coincide with these have not been found.

The prominent bands in the spectrum of *Mira* have been considered by some observers as a series of dark bands, with sharp edges toward the violet, and shading off toward the red. Others think them to be bright flutings like those of the arc spectrum of carbon. For convenience, they will be considered, in this paper, as dark absorption bands. On the plates of o *Ceti* and other third-type stars taken with Spectrograph I, the bright portions of the banded spectrum are certainly brighter relative to the region above $H\gamma$, where there are no bands, than are the corresponding portions of the spectrum of a solar-type star. However, the dark portions are fainter than the same places in the solar type of spectrum.

No attempt was made to determine the position of the more diffuse ends of the bands. In many cases the intensity changes gradually from head to head, there being heavy absorption at the sharp edge, the spectrum growing uniformly brighter to the next line of demarcation.

Sidgreaves, on comparing the spectrum of *o Ceti* with that of *α Herculis* and other third-type stars, found a difference in the wave-length of the same band in different stars. For the head at λ 5447 in *o Ceti,* he found the position of λ 5458 in *α Herculis,* and intermediate values for *α Orionis* and *β Pegasi.* He suspected these discrepancies to be due to instrumental causes, but of this he was not certain. His work being done with an objective prism, he had no comparison spectrum with which to test the reality of the observed differences.

Along with the work on *o Ceti* in 1902, plates were taken of *α Herculis, β Pegasi, ρ Persei, α Ceti,* and *α Orionis.* As these stars are all bright, the exposures on them were comparatively short, from five minutes to one hour. Isochromatic plates were used, so that a range of spectrum as far to the red as λ 5600 was covered. They were measured only for the positions of the heads of the bands. In the spectrum of *Mira* there are few dark lines shown in the region of the bands, but in the others many lines were recorded. Where there are more lines the bands are less prominent, and in the case of *α Ceti* and *α Orionis,* only three bands could be measured, while twenty-one were measured in the spectrum of *o Ceti.*

The measures of the bands give accordant results for the different stars, and in but few cases is there a discrepancy of more than one tenthmeter. My measures of the band near λ 5447 give λ 5446.8 from five stars, no star giving a value differing as much as one tenthmeter from the mean. *o Ceti* gives exactly the same wave-length as the mean of the others.

As far as I know, the identification of the bands of the third-type stars has not been accomplished. If the division at λ 5165.9 be considered as the head of a bright band, it is in close agreement with the head of the third carbon band at λ 5165.3, as measured by Kayser and Runge. The head at λ 4737.1, measured in *α Herculis,* may also correspond to their fourth carbon band, λ 4737.2. These two coincidences are the only ones I have found, and we certainly need more evidence before drawing any conclusions from them.

Sidgreaves found that the continuous part of some regions of the star's spectrum changed in relative intensity as the star grew fainter. These changes have been verified in the present work.

SIDGREAVES's plates showed that as the star declined in brightness, the intensity of the bright portions of the spectrum between λ 4300 and λ 5000 grew less relatively to that of the region near λ 5500. My plates show a decrease in intensity of the region from λ 4300 to λ 5000 relative to the continuous spectrum from λ 4000 to λ 4300.

These changes in intensity have been described as changes in the continuous spectrum, but they may be simply the fading out of some bright bands.

The most noticeable and interesting features in the spectrum of *o Ceti* are the bright lines. The great brilliancy of some of the hydrogen lines, when the star was near its maximum, has been recorded by several observers. The peculiar fact was noticed, that H_α, $H\beta$, and H_ϵ were apparently missing, while others of the hydrogen series were very bright. Photographs, which showed H_γ and H_δ as intense, gave no trace of $H\beta$ and H_ϵ. SIDGREAVES, in 1898 and 1899, found something which from its position might be the bright $H\beta$, but he did not consider it as certain. It has been seen bright on some plates at Harvard. [Vol. 28, Part I, H. C. O.] Mr. WRIGHT found H_ϵ distinctly bright on a plate which he had taken in August, 1901. $H\beta$ and H_ϵ were recorded as bright lines on all the dense negatives taken with Spectrograph I. They seem to have grown stronger relatively to the other hydrogen lines and also to the continuous spectrum as the star grew faint.

An attempt was made to observe H_α visually, but without success, on the night of September 6, 1902, when the instrument was changed to adapt it for visual work. Corresponding to the bright well-defined H_α of the comparison spectrum there was continuous spectrum, but no bright line in the star. Mr. WRIGHT was present and verified the observation. H_α should be looked for when *Mira* is again at a maximum.

The wave-lengths of the bright lines show no more change than do those of the dark lines. The average residual for each plate has been computed and there is no sign of variable position. A comparison of these average residuals with those of the dark lines is as follows:—

Date.	Plate No.	Dark Lines.	Bright Lines.
1902, July 6	7 C	+0.02	+0.01
16	13 E	+0.06	+0.04
Aug. 4	25 F	—0.03	—0.03
11	27 D	—0.02	—0.03
25	28 D	—0.03	+0.03
1901, Aug. 17	2235 D	+0.02	—0.04

These average residuals are all so small that the agreement in sign for some cases is of little significance.

The wave-lengths of the bright lines and the identification of some of them is given in the following table.

There can be no doubt that the hydrogen series is present. Metallic lines which seem to coincide in five cases are given, but in spite of the accuracy of the measures, we must consider the question of their identity to be still open.

IDENTIFICATION OF BRIGHT LINES.

o Ceti λ.	Tabular λ.	Displacement. tm.	Substance.	Authority for λ.
3751.2–	3750.15	+1.0–	H_κ	AMES.
3771.52	3770.7–	+0.82	H_ι	AMES.
3798 76	3798.0–	+0.76	H_θ	AMES.
3836.20	3835.6–	+0.60	H_η	AMES.
3853.51				
3889.91	3889.15	+0.76	H_ζ	AMES.
3906.36	3905.66	+0.70	Si 12	ROWLAND.
3908.18				
3933.45				
3939.10				
3968.49				
3970.87	3970.18	+0.69	H_ϵ	ROWLAND.
4007.74				
4102.66	4101.89	+0.77	H_δ	WRIGHT.
4202.91	4202.20	+0.71	Fe 8	ROWLAND.
4216.71				
4234.12				
4308.70	4308.08	+0.62	Fe 6	ROWLAND.
4341.33	4340.63	+0.70	H_γ	ROWLAND.
4373.61				
4376.78	4376.11	+0.67	Fe 6	ROWLAND.
4571.82	4571.26	+0.56	Mg 5	ROWLAND.
4862.34	4861.53	+0.81	H_β	ROWLAND.

It should be noticed that a bright line developed on each side of each of the strong dark calcium lines, *g, H,* and *K.* Without looking at the plates, this might seem to be due to a double reversal of the calcium lines. Their appearance is not such, however. Mr. WRIGHT also examined the plates with this in mind, and in his judgment the lines are separate bright lines and the phenomenon is not one of double reversal.

Several attempts were made, in June and July, 1902, to secure photographs of the spectrum of *Mira,* with the regular three-prism instrument. It was impossible, however, to make an exposure long enough to record the continuous spectrum. The only features recorded were $H\gamma$ and two other bright lines. $H\gamma$ was single on all the plates. It seemed nearly monochromatic, but was a little sharper on the violet than on the red side. It had the same appearance as that found by CAMPBELL in 1898, at about the same interval after the star's maximum. In 1898 he found that $H\gamma$ was triple from five to two weeks before maximum. Before observations of *o Ceti* were begun in 1902, it had been intended to make polariscopic tests for Zeeman effects in the bright lines; but they were found single on the first photographs, and no observations for polarization were attempted. These should certainly be made when it is again possible to observe the star at maximum. Measures of the three-prism plates give the following displacements of $H\gamma$ in tenthmeters.

Date.	Plate No.	tm.
1902, July 2	2446 F	+0.65
2	2447 A	+0.68
21	2470 D	+0.65
Aug. 18	2505 E	+0.61
	Mean	+0.65

It is interesting to compare the measures of plates taken in 1902 with those of 1898. CAMPBELL also observed the bright lines near λ 4308 and λ 4376. They were also measured on the high-dispersion plate of August 18, 1902. In the following scheme, under the heading "Bright Lines," is given the actual observed displacement of each bright line, corrected for the Earth's motion. Under "Dark Lines" is given an assumed displacement which corresponds to that of the absorption-lines in the spectrum.

	CAMPBELL, 1898.		STEBBINS, 1902.		
	Three Prisms.		Three Prisms.	One Prism	
	Bright Lines:	Dark Lines, +62km.	Bright Lines.		Dark. Lines, +66km.
Line.	tm.	tm.	tm.	tm.	tm.
H_δ 4101.89	+0.64	+0.85	......	+0.77	+0.90
Fe? 4308.08	+0.60	+0.89	+0.61	+0.62	+0.95
H_γ 4340.63	+0.64	+0.90	+0.65	+0.70	+0.96
Fe? 4376.11	+0.61	+0.91	+0.66	+0.67	+0.96

The dark lines in this region of the spectrum are apparently displaced about 0.25 tenthmeter farther to the red than are the bright lines. The results obtained with one prism are systematically larger than those obtained with three prisms. This may be partly due, in the case of H_γ and H_δ, to over-exposure on many of the plates. Since the lines seem to shade off toward the red, greater exposure probably slightly increases the apparent wave-lengths. However, since the displacements of the other hydrogen lines, which were not over-exposed, are about the same as those of H_γ and H_δ, this effect is probably not large. The difference between the results of 1898 and 1902 is due, no doubt, to personal errors.

The bright lines at λλ 4308 and 4376, marked as possibly due to iron, are of peculiar interest. The appearance of each, on some of the plates, is of a bright line with an adjacent dark one on the red side. If the bright lines be due to iron, they are displaced by the same amount as the bright hydrogen lines; and if iron produces the absorption components, the displacements are equal to those of other dark lines.

A glance at the series of plates showed that there were many changes of intensity among the bright lines, both relative to each other and to the continuous spectrum. The lines at λλ 4202, 4308, and 4571 all became brighter than the hydrogen lines. Of these three, only λ 4202 was visible on the early plates. λ 4571 did not exist at first, but appeared when the star was of about magnitude 5.4, and as *Mira* grew faint this line became the most prominent object in the spectrum.

H_γ and H_δ could not be seen on plates taken near minimum, although they were easily observed a month before. On account of underexposure it can not be said whether the other bright hydrogen lines disappear or not.

Until this star has been successfully followed through all its phases, it is obviously too soon to advance any theory to account for the observed changes in its spectrum or in its brightness. The light-gathering power of the great refractor is not sufficient to follow the spectrum satisfactorily, at least not on the dispersive scale used by me. An ideal equipment for work on variables would consist of a large reflector which could be used for this purpose alone, with spectrographs of various dispersive powers arranged for use in all parts of the spectrum.

The apparent constancy of radial velocity is strong evidence that the variations in brightness are not due to the influence of a companion star, unless, indeed, the companion were of very small relative mass, were moving in a very eccentric orbit, and approached very close to the primary. The displaced system of bright lines could not belong to such a companion, as their wave-lengths are apparently constant. The large irregularities in the period of the light-curve practically preclude the question of a binary system, though perhaps not absolutely so.

The remarkable distribution of light in the hydrogen series seems as yet impossible to explain. Miss CLERKE has explained the apparent absence of H_ϵ by assuming the hydrogen to be at a lower level in the star's envelope than the calcium layer, the *H* calcium absorption destroying the H_ϵ radiations. This theory may still be true, though the existence of a faint bright H_ϵ has been proven. However, $H\beta$ and H_α are much more reduced in intensity than is H_ϵ; and with them there is no evidence of overlying absorption strata. It is usually expected that the bright hydrogen series will diminish in intensity from red toward the violet. This appears to hold even for new stars, in which the disturbance has been very sudden, though exception should perhaps be made for H_α when new star spectra approach the nebular form. The supposition that in *Mira* the hydrogen series may regularly decrease in brightness from violet to red is not tenable, as the diminution from H_γ to $H\beta$ is entirely too great. Inasmuch as the bright lines are strongly shifted (to the violet with reference to the dark-line system) from their normal positions apparently by causes other than radial velocity and pressure, it seems probable that the peculiarities of the hydrogen-line intensities are due also to causes now unknown to us. The presence of the bright iron lines λ 4202, λ 4308, and λ 4376, the absence of others of the same element, and the diversity of structure observed by CAMPBELL in the triple H_γ and H_δ bands are perhaps due to similar unknown causes.

The great variations of relative intensity observed in the hydrogen and other bright lines, and in the continuous spectrum, show that the star's decrease in light is produced by other causes than general absorption.

Considering all the evidence, it seems reasonably certain that the star's variation in brightness is due to the action of internal forces.

I beg to acknowledge my indebtedness to Director CAMPBELL, who provided the necessary apparatus and made valuable suggestions during the course of the work; to Messrs. WRIGHT and REESE, for continual advice and assistance; and to Dr. H. D. CURTIS, for enlarging the negatives for reproduction.

May 1, 1903.

NOTES ON VARIABLE STARS.

By ROSE O'HALLORAN.

Y Cassiopeæ.

The variation of this star, which was discovered on the photographic plates of Harvard College Observatory a few years ago, ranges from 9.8 to 13th magnitude.

According to the comparison-stars of 10.2 and 12th magnitude close above, it was of 11.3 magnitude on the 1st and 2d of August, in 1902, and on October 26th and 31st, and November 3d it had increased to 11th magnitude.

W Aurigæ.

Having become invisible in last December, the predicted maximum was looked for towards the middle of January of this year.

On the 14th, 17th, and 27th, and on February 1st it was still invisible, though a comparison-star of 12th magnitude was seen. The period of *W. Aurigæ* seems to be irregular.

S S Cygni.

This fitful variable was nearly equal to *b* of 8.5 magnitude recently, but has since declined.

1903. June 23, 8:50 P. M.—Two tenths less than *b*. June 24, 25, 26—Decreased, but still brighter than *a* of 9.5 magnitude. June 27, 29—Equal to *a*. June 30, 9:17 P. M.—Slightly less than *a*, but distinctly brighter than *d* of 10.5 magnitude. July 1—Between *a* and *d*, but nearer to *d*. July 2—Dimmer in haze and moonlight; *d* not seen. July 3—Barely discerned in haze and moonlight. July 4, 5—Equal to *d* in hazy moonlight. July 6—Less than *d*, clear moonlight.

W Lyræ.

The recent increase and decline of this star was observed as follows:—

1903. February 21—8.8 magnitude; not equal to *a*; equal to *e*. February 28—8.6 magnitude; brighter than *e*, equal to *a*, less than *n*. Morning clear. March 6, 9, 18, 22—Still equal to *a*. Mornings rather clear. March 25—8.7 magnitude; slightly decreased. April 3—8.8 magnitude. April 11—9th magnitude, according to the comparison-stars. April 22—9.8 magnitude. May 1—10.5 magnitude. May 12—11th magnitude. June 1st—About 12th magnitude; barely visible. June 17, 22, 25, 29—Not visible. July 1, 2, 3—Not visible. July 6—In clear moonlight not visible with a high power.

Classified comparison-stars not being available for the following variables, namely, *W Cassiopeæ*, *V Coronæ*, and *V Hydræ*, the estimates are founded only on experienced observations. Except in the case of *V Hydræ*, the comparison-stars used were closely adjacent to the variables.

W Cassiopeæ.

1902. August 22—11.5 magnitude. September 25, 27—Invisible. October 26, 28, 31—Invisible. November 3—Invisible.

1903. June 24, 26, 29, 30—Of 10th magnitude. July 1, 2, 3—Of 10th magnitude.

V Coronæ.

1903. April 22—Somewhat less bright than 9th magnitude. May 1—Distinctly brighter, compared to the stars closely adjacent. It was of about 8.5 magnitude.

V Hydræ.

1903. February 4—Less than B^2 of 6th magnitude, but visible in an opera-glass, and probably of 6.7 magnitude. February 12—6.7 magnitude. Moonlight. This is the date of expected maximum. February 19, 23, 25, 26—6.7 magnitude. March 3, 6, 16—6.7 magnitude. April 1—Slightly decreased in telescope and still more decreased in opera-glass. April 11, 16—Ditto. April 26—Of about 7th magnitude, but still visible in opera-glass.

San Francisco, July 7, 1903.

PLANETARY PHENOMENA FOR SEPTEMBER AND OCTOBER, 1903.

By Malcolm McNeill.

PHASES OF THE MOON, PACIFIC TIME.

Full Moon,	Sept.	6,	$4^h 20^m$ P.M.	Full Moon,	Oct.	6,	$7^h 24^m$ A.M.
Last Quarter,	"	14,	5 14 A.M.	Last Quarter,	"	13,	11 56 A.M.
New Moon,	"	20,	8 31 P.M.	New Moon,	"	20,	7 30 A.M.
First Quarter,	"	28,	5 8 A.M.	First Quarter,	"	28,	12 32 A.M.

The Sun reaches the equinox and autumn begins September 23d, 10 P. M., Pacific time.

There will be a total eclipse of the Sun on September 20th, but it will not be available for astronomical observations, as the path of totality lies in the most inaccessible region of the globe. It begins in the Indian Ocean, southeast of Africa, and runs eastward and then southward, ending near the South Pole. There is very little land from which even the partial phase of the eclipse can be seen; Madagascar and the southern portions of Australia and New Zealand are about all.

There will also be a partial eclipse of the Moon on October 6th, rather uninteresting to people in the United States, since no part of it will be visible here. It will be visible throughout most of the eastern hemisphere and will be not quite total.

Mercury begins the month as an evening star, coming to greatest east elongation on September 7th. It is then 27° from the Sun, but it is also 10° south; so it remains above the horizon scarcely an hour after sunset, and will not be easily seen. It soon begins to approach the Sun quite rapidly, and passes inferior conjunction on October 3d, becoming a morning star. On October 18th it reaches its greatest west elongation, 18°. This is much smaller than the last; but now the planet is in a part of the zodiac north of that part where the Sun is, and consequently there is a much wider interval between the times of rising of the two bodies. During the latter half of the month *Mercury* will rise from an hour and a half to an hour before sunrise, and this will be the best time of the year for seeing the planet as a morning star.

Venus is an evening star at the beginning of September, too close to the Sun to be seen. It reaches inferior conjunction on September 17th, and becomes a morning star. Its motion is now northward and westward from the Sun, and in a very few days it can be seen in the morning twilight. On October 1st it rises an hour and a half before sunrise, and by November 1st more than three hours and a half. During October it will also be very bright, reaching the maximum on October 24th, and it may be seen in full daylight during the greater part of the month. At the time of inferior conjunction *Venus* is nearly 6° south of the Sun, being in the part of its orbit farthest from the ecliptic. Although the inclination of the orbit of *Venus* to the ecliptic is less than half that of *Mercury* (the greatest in the solar system except the asteroids), yet on account of its nearness to us at inferior conjunction it can attain a greater apparent distance from the ecliptic than any other planet. It is frequently stated in text-books that this distinction belongs to *Mercury,* but it is *Venus* which reaches the greatest latitudes.

Mars is still an evening star, but the Sun is gradually overtaking it in their common eastward motion. On September 1st it sets shortly after 9 P. M., on October 1st an hour earlier, and on November 1st before 8 P. M., less than three hours after sunset. Its total motion during September and October is about 45° eastward and 7° southward, from *Libra* through *Scorpio* into *Sagittarius.* On September 25th it passes about 2° south of *β Scorpii,* and on October 3d about 4° north of *Antares, α Scorpii.* Its distance from the Earth in millions of miles increases from 139 to 167, and in consequence of this its brightness will diminish nearly 50 per cent, but there will be no difficulty in identifying it.

Jupiter comes to opposition with the Sun on September 11th, and is then above the horizon the entire night. Toward the end of October it will set an hour or more before sunrise. It is in the constellation *Pisces,* and during the two months moves about 6° westward and 2° southward.

Saturn is also in good position for evening view. It sets at about 2:30 A. M. on September 1st, at about 12:30 on October 1st, and at about 10:30 P. M. on November 1st. It is in the constellation *Capricorn,* and moves slowly westward until October 7th, and then moves eastward, but the whole range of motion is about 1° only.

Uranus is nearer the horizon than *Saturn,* setting shortly after 11 P. M. on September 1st, and at about 7:30 on November 1st. It is moving slowly eastward in *Ophiuchus* between *Scorpio* and *Sagittarius. Mars* passes it on October 24th, the brighter planet being about two diameters of the Moon farther south.

Neptune rises shortly after midnight on September 1st and at about 8:30 P. M. on November 1st. It is in the western part of *Gemini,* and moves slowly eastward until October 9th, and then begins to move westward.

(FORTY-FIFTH) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to JOHN GRIGG, Esq., of the Observatory, Thames, New Zealand, for his discovery of an unexpected comet on April 16, 1903.

The Committee on the Comet-Medal:

W. W. CAMPBELL.
WM. PIERSON.
CHAS. BURCKHALTER.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

COMET *c* 1903 (BORRELLY).

A telegram announcing the discovery of a new comet by M. BORRELLY, at Marseilles, on June 21, 1903, was received here on the evening of June 22d. Observations of it were secured by the writer the same night and the two following nights, and the resulting positions telegraphed to other observatories. The comet at the date of the first observation was in the position R. A. 21^h 52^m; Decl. $-7°$, and was moving slowly westward and more rapidly northward. It appeared to be fully as bright as an eighth-magnitude star, and had a small disk-like nucleus estimated of about the tenth magnitude. A brushy tail could be traced for half a degree in the south preceding quadrant.

The comet's apparent motion has increased very rapidly, owing to its near approach to the Earth, with a corresponding increase in its brightness. On June 30th it was easily visible to the naked eye, and last night (July 14th) it was as bright as a third-magnitude star. Notes on the comet's orbit, and on the photographic and spectrographic observations secured here will be found on another page.

July 15, 1903.

R. G. AITKEN.

THE PHOTOGRAPHIC SPECTRUM OF COMET *c* 1903 (BORRELLY).

A photograph of the spectrum of this comet was obtained on July 15th, using the small slit-spectrograph attached to the Crossley reflector. An exposure of four hours showed the five bands which were photographed in comets *b* 1893 (RORDAME)† and *b* 1894 (GALE)‡, by CAMPBELL. The relative

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[*] Lick Astronomical Department of the University of California.

[†] *Astronomy and Astrophysics*, Vol. XII, p. 652.

[‡] *Astronomical Journal*, Vol. XIV, p. 111.

intensities of these bands are also the same, with one exception, allowing for the differences of dispersion and absorption of the instruments used. The band at λ 420 is quite conspicuous in both of the earlier comets, but is very weak in Comet Borrelly.

Very little continuous spectrum is shown in the photograph, although it seemed quite strong in the visual portion of the spectrum.

C. D. P.

July 19, 1903.

ELEMENTS OF COMET *c* 1903 (BORRELLY).

The following orbit was computed from observations made on June 22d, 30th, and July 10th, by Dr. AITKEN:—

$$\begin{array}{rl} T = & 1903, \text{ August } 27^d.6056, \text{ Gr. M. T.} \\ \omega = & \left.\begin{array}{lll} 127^\circ & 19' & 25''.5 \\ \Omega = 293 & 32 & 55.0 \\ i = 84 & 59 & 45.3 \end{array}\right\} 1903.0 \\ \log q = & 9.518126 \end{array}$$

Residuals (O − C):—

$$\begin{array}{ll} \Delta\lambda' \cos\beta' & -1''.0 \\ \Delta\beta' & +5\;.7 \end{array}$$

The orbit of this comet bears no close resemblance to any previously observed.

An extended ephemeris shows that the comet reaches a north declination of over 68° on July 20th. It then turns south, with diminished geocentric motion, and at the time of perihelion is still 15° north of the Sun on almost the same meridian. It will thus be visible as an early evening object until after its perihelion passage, after which it will become a morning object for a few days. As its southward motion is rapid, it will soon after be lost to northern observers.

Its theoretical brightness reached a maximum on July 17th, when it was fourteen times brighter than at discovery. At perihelion its theoretical brightness is 8. Its observed brightness will, in all probability, be greater than theory indicates.

July 19, 1903. C. D. P.

PRELIMINARY NOTE ON PHOTOGRAPHIC OBSERVATIONS OF COMET *c* 1903 (BORRELLY).

Photographic observations of Comet *c* 1903 (BORRELLY) were begun at the Lick Observatory on the night succeeding that of discovery, and are still in progress. Nine exposures, ranging in length from thirty-eight minutes to four hours, have been made with the Dallmeyer camera of 15^{cm} aperture, 82.6^{cm} equivalent focal length, and 14° × 16° angular field. Three negatives with the same range of exposure have been obtained simultaneously with the Floyd camera of 13^{cm} aperture and 178^{cm} focal length.

Two tails, one of which is nearly straight, the other greatly curved, appear on all but the last plate. The curved tail is short and very bright, while the straighter tail is relatively fainter and longer but develops some very interesting forms.

On a plate of four hours' exposure, on June 23d, the tails are widely separated. The straight tail is narrow at the head, but broadens and extends 1½ degrees. On the plate of June 29th the longer tail has split up into two distinct branches, which emerge separately from the head and diverge slightly as they extend into space. With four hours' exposure on June 30th, the secondary tail appears very bright, with a length of 1½ degrees. The primary extends five degrees from the nucleus. The form is indistinct, but the division of the previous night still persists. One branch remains straight, while the other is broader and longer and follows a sinuous curve. On the following night the straight tail is sharp and single.

The plates of July 12th and 13th still show two tails. The primary tail is straight and narrow, and the secondary tail still greatly curved. On the plate of July 12th, with thirty-eight minutes' exposure, the primary tail is four degrees long; the secondary tail is 1.5 degrees in length. The plate of July 14th, $1^h\ 48^m$ exposure, shows one straight narrow tail 8½ degrees in length, widening out slightly as it extends away from the head.

On all the plates the nucleus is sharp and approximately central with respect to the heavy coma.

During these exposures the Earth has been approaching rapidly to the plane of the comet's orbit. At the same time the apparent angle between the tails has steadily diminished until, on the plate of July 14th, they are coincident. Measures of the position-angles of the tails on two plates are given below. P_a, P_b, and P_r represent respectively the position-angles of the primary tail, secondary tail, and radius vector from the

Sun to the comet. The difference $P_a - P_r$ appears in the last column.

No. of Plate.	Date, 1903.	P. S T. of Mid-exposure.	α	δ	P_a	P_b	P_r	$P_a - P_r$
5	June 30	$13^h 33^m$	$21^h 41^m.5$	$+ 2° 48'$	236°.0	216.8	238.0	—2°.0
7	July 12	8 52	20 34 .2	+39 23	197 .3	188.0	199 6	—2 .3

R. H. CURTISS.
SEBASTIAN ALBRECHT.

HONORS CONFERRED UPON MEMBERS OF THE LICK OBSERVATORY STAFF.

The honorary degree of Doctor of Science was conferred upon Assistant Astronomer R. G. AITKEN in May by the University of the Pacific.

Astronomer W. J. HUSSEY was elected Foreign Associate of the Royal Astronomical Society at their meeting May 8, 1903.

W. W. C.

APPOINTMENTS TO LICK OBSERVATORY STAFF.

Dr. JOSEPH H. MOORE, recently of Johns Hopkins University, has been appointed Assistant in Spectroscopy.

JAMES D. MADDRILL, University of California, Class of 1903, has been appointed Fellow in Astronomy in the Lick Observatory for the current academic year.

W. W. C.

D. O. MILLS EXPEDITION TO CHILE.

Acting Astronomer WRIGHT, in charge of the D. O. Mills expedition to Chile, has selected the summit of the hill San Cristobal as the site for the observing station. This hill lies on the northeast edge of the city of Santiago. The altitude of Santiago is 560 meters, and that of San Cristobal about 850 meters. There is a road to the top. "The summit is a ridge about one fourth of a mile long, with three peaks, not unlike Mt. Hamilton."

W. W. CAMPBELL.

MT. HAMILTON, July 17, 1903.

GENERAL NOTES.

Personal Scale.—Almost every observer has a tendency, in estimating the tenths of intervals on scales or micrometer heads, to slight certain tenths and to favor others. This tendency has been called "personal scale" by Peirce, who first called attention to it. Not much has been written on the subject, probably because, although very interesting from a psychological point of view, it can never have much effect on observations. Usually all that personal scale does is to increase, in a slight degree, the probable error of one observation.

The writer examined 2,000 readings that he made on a micrometer attached to the zenith telescope at the International Latitude Station at Ukiah. The following table shows the number of times that each tenth was read off (reduced to percentages of the whole). If he had had no personal scale all these numbers should have been 10.0 per cent. The readings were counted in four independent sets of 500 each, in order that their accordance might show the degree of reliability of the means:—

Tenths.	First 500.	Second 500.	Third 500.	Fourth 500.	Mean.
.0	14.1	15.2	14.3	10.0	13.4
.1	11.2	7.4	11.3	9.5	9.8
.2	8.0	10.2	7.9	9.3	8.9
.3	8.4	5.8	8.5	9.5	8.0
.4	13.5	11.2	11.9	11.2	12.0
.5	12.7	15.0	12.9	15.4	14.0
.6	13.1	11.6	11.3	14.2	12.6
.7	4.8	7.2	7.9	5.5	6.3
.8	5.8	9.0	6.6	7.3	7.2
.9	8.4	7.4	7.4	8.1	7.8

It will be seen that this observer tends to slight the high tenths (0.7, 0.8, and 0.9) and to favor 0.0, 0.5, and the two adjoining 0.5. It may be remarked that the tendency to favor 0.0 and 0.5 is the most usual form of this kind of personality.

Personal scale extends to the estimation of tenths of a second in observing transits by the eye-and-ear method. Dr. S. D. Townley has published (*Astronomy and Astrophysics*, June, 1892) a series of about one thousand such estimations, with the following result:—

Tenths.	Per cent of whole.
.0	15.5
.1	10.3
.2	11.5
.3	11.1
.4	7.9
.5	10.1
.6	10.2
.7	8.3
.8	6.9
.9	8.2

There is here a tendency to slight the high tenths and to favor the zero. It is a somewhat remarkable feature that all the missing sevens, eights, and nines have been called zeros.

Neither of the above personal scales is very marked. The writer came upon a case some time ago of an experienced observer in whom the tendency was particularly strong and very curious. The following shows the results of two independent counts of micrometer bisections, each count embracing 608 estimations:—

Tenths.	Per cent.	Per cent.	Mean.
.0	16.3	21.6	19.0
.1	19.9	16.2	18.0
.2	19.6	19.9	19.8
.3	1.8	2.3	2.0
.4	6.4	1.7	4.0
.5	0.3	0.5	0.4
.6	3.4	1.8	2.6
.7	2.4	3.4	2.9
.8	11.3	18.1	14.7
.9	18.6	14.5	16.6

The crowding to the ends of this scale is very remarkable. This observer apparently had such an aversion to 0.5 that out of 1,216, when it should have been read 122 times, it appears only five times! We should, then, naturally expect that 0.4 and 0.6 would be read more often than they actually occurred, but instead we find that these, as well as 0.3 and 0.7, have been badly neglected. If we add up the percentages for 0.3, 0.4, 0.5, 0.6, and 0.7, we get 11.9; consequently, almost all these readings should actually have been called 0.5. That an experienced observer could have so marked a personal scale is almost incredible, but perhaps it is no more difficult to believe this than to understand the statement regarding BESSEL'S personal equation. It is said that when he used a clock beating half-seconds his personal equation changed as much as 0.49 seconds compared to what it was with the use of a clock beating seconds. If it were almost anybody but BESSEL we should be inclined to think that a cog had slipped somewhere.

F. S.

ANDREW AINSLIE COMMON, LL.D., F.R.S., died suddenly at Ealing, London, on June 2d last. He was born at Newcastle-on-Tyne in 1841. Though an engineer by profession, his strong bent for astronomy declared itself in early manhood, and became practically the pursuit of his life. His home and his observatory were at Ealing, where he had a fine equatorial telescope at work, and devoted himself especially to celestial photography. The satellites of *Mars* received particular attention, also those of *Saturn,* the nebula in the *Pleiades,* and the great one in *Orion,* with some new stars near that constellation. He also studied the nucleus of the noted comet of 1882,—all researches of a kind in which photography would be of special service. On the practical side, Dr. COMMON wrote on the illumination of micrometers, on silvering large mirrors, on the mounting of large telescopes and reflectors, and, at a later date, on the mounting of a three-foot reflector. He was the maker of some very important reflecting equatorials, including the largest of its kind in existence. Elected a Fellow of the Royal Astronomical Society in 1876, he was its President in 1895-96, and mentioned in a report presented in the following year that the five-foot mirror of his direct Cassegrain telescope had been reground, and that, in addition to other concave mirrors, two of thirty inches diameter had been made. In recognition of his work on Celestial Photography, he received the gold medal of the Royal Astronomical Society. Since 1895 he had devoted his attention to the improvement in the sighting of guns of all kinds, and he recently patented a range-finder, which was taken up by the Admiralty. ANDREW GREIG.

FRIEDRICH DEICHMÜLLER, professor at the University of Bonn, and observer at the observatory, is dead. He had been connected with the observatory for nearly twenty-seven years, his chief work there being upon Part Six (40° to 50°) of the *Astronomische Gesellschaft Catalog.* This work contains 50,000 observations on 18,457 stars. DEICHMÜLLER made one third of the observations and superintended all the reductions. Of late years his attention had been given almost exclusively to variable stars and to corrections to the *Durchmusterung.* He died in the prime of life, having been born in 1855.

ANDREW GRAHAM, for many years chief assistant at Cambridge Observatory, is retiring at the age of eighty-eight. More than fifty-five years ago, Mr. GRAHAM'S name became widely known as the discoverer of *Metis,* the ninth asteroid. His chief contribution to astronomy is his work on Part Nine (25° to 30°) of the *Astronomische Gesellschaft Catalog.* All the observations on the 14,464 stars it contains were made by himself, besides which he performed or supervised all the computations.

Lady HUGGINS and Miss A. M. CLERKE were made honorary members of the Royal Astronomical Society at its last meeting. This is a rare honor, having been accorded on only two previous occasions—to Mrs. SOMERVILLE and to CAROLINE HERSCHEL.

The University of Glasgow has conferred the degree of LL.D. upon Sir NORMAN LOCKYER, Director of the Solar Physics Observatory, London.

The two independent determinations of the difference of longitude between the observatories at Paris and at Greenwich have been completed and are shortly to be published,—the one by M. LOEWY and the other by Mr. CHRISTIE, the respective directors of these observatories.

The new cable to Hawaii offers an opportunity for the determination of the longitude of this place which the U. S. Coast and Geodetic Survey has already taken advantage of. The work is now completed, Assistants SMITH and MORSE having each observed both at Honolulu and San Francisco.

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NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.
(February, April, June, August, October, December.)

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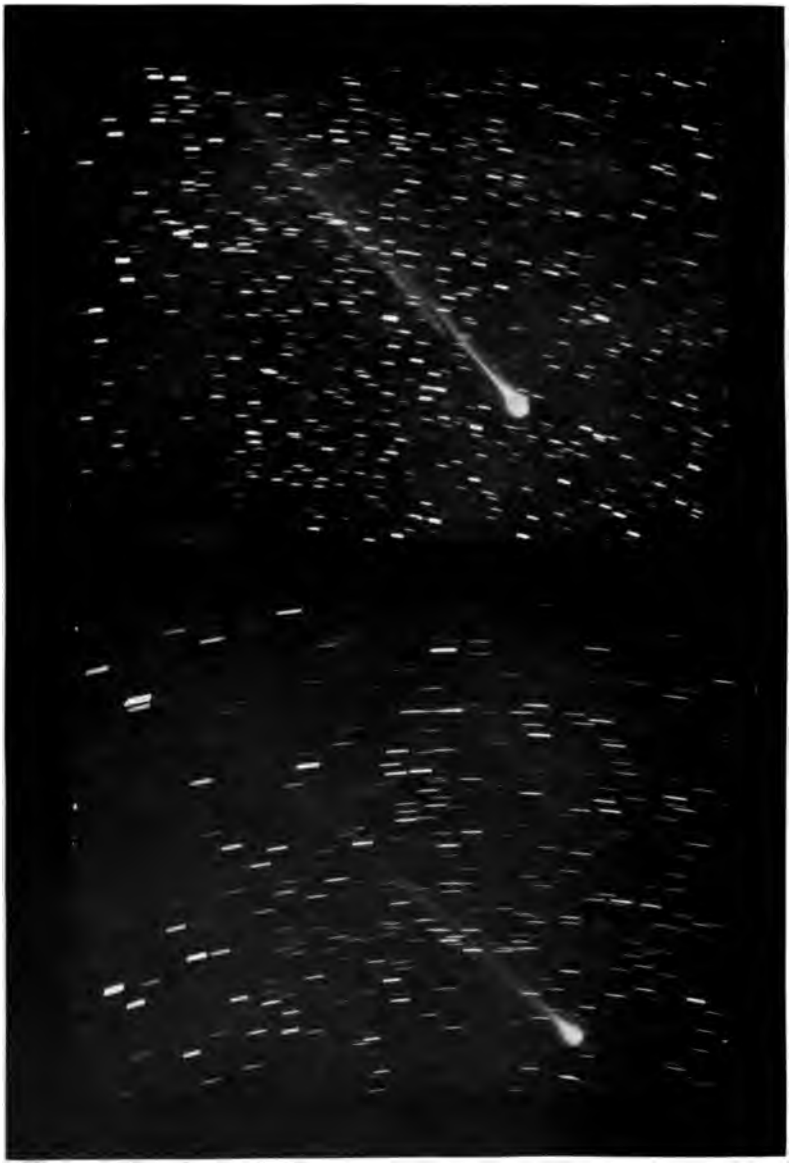

Comet *c* 1903 (BORRELLY)

From negatives by R. J. WALLACE

1. 1903 July 22: 12 hr. 1 m.—14 hr. 31 m. Cent. St. Time
2. " " 24: 11 hr. 59 m.–14 hr. 29 m. " "

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. XV. SAN FRANCISCO, CALIFORNIA, OCTOBER 10, 1903. No. 92.

PHOTOGRAPHS OF COMET *c* 1903 (BORRELLY).

By R. J. WALLACE.

Through the courtesy of Professor E. E. BARNARD, the writer was privileged to make use of the camera and lens used by him for the purpose of continuing the series of negatives of Comet *c* during a portion of the month of July, which portion of time was fortunate enough to embrace the most interesting period of the comet's career, at least from a pictorial point of view.

The lens referred to is that belonging to a projection lantern manufactured by the Mackintosh Optical and Battery Company, of Chicago, and is the property of Director GEORGE E. HALE. Being of short focus with relatively large aperture, —viz., 1.6 inches diameter, with 6.3 inches focus,—it thus gives a wide field of fairly large area upon the plate and with excellent definition.

Upon the date of July 20th a negative taken by the writer shows clearly the tail extending to about 9°, single, and with no particular structure (exposure-time, 2^h 25^m), while that upon the evening following is not distinguished by any particular change (exposure-time, 2^h 15^m).

On the plate of July 22d a distinct change was observable, in that the tail had split up into four separate streamers, emanating from the head and trailing off into space with varying lengths readily measurable from 6°.5 to 16°. The exposure-time was 2^h 31^m, with a fairly good sky.

The negative of the ensuing evening (July 23d) was marked by a division of the tail into three, one of which was very faint but yet distinctly traceable, and extending to a distance of about 14°. Exposure-time, 2^h 2^m with a fair sky.

The record of the 24th showed a marked change, the tail having the appearance of being broken off transversely at a distance of 3° or 4° from the head, the inclination of the following division differing by about 2° from the direction of the longitudinal axis of that preceding. That this separation was taking place at a very rapid rate is shown by the negative of Professor BARNARD of that same evening, and preceding that of the writer by a mean of $3^h\ 0^m$, wherein the separation is shown very decidedly but only about 0°.3 wide, as against 0°.5 in the later negative.

Such a phenomenon was naturally the cause of much anticipatory interest in the results of the following evening, but by that time (according to a negative by Professor BARNARD) the tail had apparently completely coalesced, and from then on there is nothing recorded of unusual interest.

It may further be mentioned that prints from all pairs of negatives taken by Professor BARNARD and the writer, when properly matched, give perfect stereoscopic effect when so viewed, the comet hanging suspended considerably in front of the stars, and the structure of the tail clearly showing. Lack of space prevents the reproduction here of such a print.

All negatives were made upon Seed 27 gilt-edge plates, backed, reduced with hydrochinon liberally restrained with bromide, carefully shielded from the dark-room light, and developed until the appearance of chemical fog indicated the maximum effect.

YERKES OBSERVATORY, September 25, 1903.

PLANETARY PHENOMENA FOR NOVEMBER AND DECEMBER, 1903.

BY MALCOLM MCNEILL.

PHASES OF THE MOON, PACIFIC TIME.

Full Moon,	Nov.	4,	$9^h 27^m$ P.M.	Full Moon,	Dec.	4,	$10^h 13^m$ A.M.
Last Quarter,	"	11,	6 46 P.M.	Last Quarter,	"	11,	2 53 A.M.
New Moon,	"	18,	9 10 P.M.	New Moon,	"	18,	1 26 P.M.
First Quarter,	"	26,	9 37 P.M.	First Quarter,	"	26,	6 22 P.M.

The Sun reaches the winter solstice and winter begins December 22d, 4 P.M., Pacific time.

Mercury is a morning star at the beginning of November, having passed greatest west elongation about a fortnight before. It rises about an hour before the Sun, and may possibly be seen under good condition of weather; but it begins to approach the Sun quite rapidly, and comes to superior conjunction on November 21st. It can therefore be seen as a morning star for only a very few days. After conjunction it swings slowly away from the Sun, as an evening star, and toward the close of December it is well out toward greatest east elongation. On December 31st it remains above the horizon an hour and a half after sunset, and for a week or so earlier the interval is more than an hour. The conditions for visibility are fairly good for the last week of December.

Venus is in fine position for observation as a morning star. It is still bright enough at the beginning of November to be seen by the naked eye in full daylight, and on November 28th it reaches its greatest west elongation, 46° 46′ from the Sun. It then rises four hours before sunrise; and at the beginning of November and the end of December the interval is only half an hour less. It moves about 60° eastward and southward among the stars, from the eastern part of *Leo* through *Virgo* and *Libra* nearly to *Scorpio*. *Venus* is in perihelion on December 11th, but, on account of the almost perfect circularity of its orbit, the variation in distance from the Sun is very small.

Mars is still an evening star in the western sky after sunset. Throughout November and December it remains above the horizon about three hours after sunset, and the interval changes only a few minutes in the two months. During this time the Sun gains about 15° on the planet in their common eastward motion; but during December the planet runs northward more than the Sun, and this keeps the interval between the setting of the Sun and of the planet about the same. *Mars* moves about 49° eastward and 7° northward among the stars, from the western part of *Sagittarius* to the eastern part of *Capricorn*. It is in perihelion on December 22d, and its distance from the Earth in millions of miles increases from 167, on November 1st, to 179, on December 1st, and 190, on December 31st. The diminution is not quite as rapid as it was during the early autumn, and it will keep on slowing up until the maximum is reached, in the spring of 1904. There will be a loss of about thirty per cent in brightness during the two months, and *Mars* will no longer be conspicuous; but it will still be as bright as a small, first-magnitude star, and easily identified in the comparatively barren region in which it is moving.

Jupiter is in fine position for observation in the southern and southwestern sky in the evening. On November 1st it does not set until nearly 2 A.M., on December 1st at midnight, and on December 31st shortly after 10 P.M. It moves very slowly westward until November 9th, and then resumes its direct eastward motion. By the end of December it has moved 4° eastward and 2° northward. It is in the western part of the constellation *Pisces,* and very few naked-eye stars are near it. At the end of December the vernal equinox is about 10° east and 6° north of *Jupiter,* and the planet will pass near that point of the heavens in the spring of 1904.

Saturn is also in the southwestern sky in the evening, but much lower down than *Jupiter,* although it may be seen without difficulty in the evening sky until the end of December. On November 1st it sets at about 10:30 P.M., at 8:40 on December 1st, and at about 7 on December 31st, the last being rather more than two hours after sunset. It is in the constellation *Capricorn,* and its motion among the stars is 5° eastward and 1° northward. Toward the close of December it is in the neighborhood of *Mars,* and there will be an interesting conjunction of the two planets on the evening of December 20th. *Mars* will pass to the south of *Saturn* from west toward east, at a distance just a trifle more than the apparent diameter of the Moon. At the time of nearest approach, the Moon, about two days old, may be seen between the planets and the western horizon.

Uranus is low down in the southwestern sky on November evenings,—too low for so faint an object to be easily seen. It passes conjunction with the Sun on December 18th, and becomes a morning star. During November and December it moves about 3° eastward into the extreme western part of *Sagittarius.*

Neptune comes to opposition with the Sun early in the morning of December 27th.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

NOTES ON SOME INTERESTING DOUBLE STARS.

Among the many interesting double stars on my observing list, the following seem worthy of special mention at this time. Nearly all of them belong to the class of rapid binaries, though in several instances we lack the data necessary for computing an orbit. All the observations here referred to were made with the 36-inch telescope, using eyepieces with magnifying powers of from 1000 to 2600, except those of 70 *Ophiuchi* and three of the measures of *ζ Herculis* in 1902, which were made with the 12-inch.

Ho. 212 = 13 Ceti.—The mean of three measures in 1902 is:—

1902.63 286°.0 0''.26

and of two recent ones:—

1903.59 306°.2 0''.18

Recalling the fact that BURNHAM did not see the close pair in 1877 when he measured a faint distant companion, nor in 1890-91 when he examined it with the 36-inch, and noting that the angular motion seems now to be increasing, with diminishing distance, it seems very possible that the revolution period may be about fourteen years. It is now a difficult object to measure even with the 36-inch telescope.

β 612.—The mean of two nights' measures made last year is:—

1902.32 249°.2 0''.17

and of five measures in the present year:—

1903.39 261°.2 0''.15

From a comparison of these results with earlier measures, it appears that the period is not likely greatly to exceed thirty years, the value found by GLASENAPP in 1892. It will be a difficult pair to measure for several years to come.

---

* Lick Astronomical Department of the University of California.

β 949.—This is another star that is now in a critical part of its orbit. When discovered by BURNHAM, in 1880, the distance was 0″.62. In 1898 I found that the distance had diminished to 0″.41. The distance has since diminished very rapidly, with comparatively little change in the angle. The star was examined on three fairly good nights during the present year, but was found too close to measure, the distance being little, if any, over $^{1}/_{10}$″. The plane of the orbit is apparently nearly in the line of sight.

Σ *2084 = ζ Herculis.*—This well-known binary has now become an easy pair, and the motion for some years will be comparatively slow. My measures for the last two years are:—

1902.46	215°.1	0″.92	4^{n}
1903.34	204 .4	1 .05	2

Σ *2272 = 70 Ophiuchi.*—My measures for the past two years give:—

1902.60	212°.3	1″.59	5^{n}
1903.54	196 .7	1 .75	3

The point of minimum apparent distance was passed early in 1901, and the distance is now steadily increasing with a corresponding decrease in angular motion.

A. 88.—The rapid angular motion of this pair continues, and the period is likely to be a short one. The mean of three recent measures is:—

1903.44 298°.4 0″.11

The position at the time of discovery was:—

1900.46 353°.2 0″.14

Winlock = ζ Sagittarii.—This interesting binary has now became an exceedingly difficult object for observers in the northern hemisphere, and in the southern hemisphere, unfortunately, there are practically no observers interested in double stars who can command telescopes powerful enough to resolve it. The following are, so far as I know, the only measures made in the past two years:—

1902.55	51°.7	0″.43	1^{n}	INNES.	(Communicated by letter.)
1902.66	47 .6	0 .36	2	AITKEN.	
1903.40	16 .5	0 .22	2	AITKEN.	

O Σ *535* = δ *Equulei.*—In No. 87 of these *Publications* (p. 198) I gave my measures of this pair to 1902.794. Since then I have measured it as follows:—

1902.873	35°.2	0″.16	
.969	30 .6	0 .18	
1903.46	28 .3	0 .28	5^{n}

The gradual increase in the angular distance which was observed the latter part of last year has evidently continued, and the star is now easily resolved with the 36-inch,—in fact, it is readily recognized as a double star with the 12-inch. Assuming the period of 5.7 years as correct, it will remain a comparatively easy pair for the next two years, and will then close in again.

β *989* = κ *Pegasi.*—Like the preceding pair, κ *Pegasi* will soon reach its greatest apparent separation, and will be well placed for observation for several years. My recent measures give the following results:—

1901.970	209° ±	0″.07 ±	1^{n}
1902.92	171 .8	0 .14	2
1903.52	139 .5	0 .14	4

A. 417 = *83 Aquarii.*—In announcing the discovery of this pair in these *Publications* (No. 86, p. 166) the value of the annual proper motion was erroneously given as 0″.023 in 17°.5. It should be, as Professor Burnham kindly pointed out to me, 0″.107 + in 78°. The same correction applies to *L. O. Bulletin* No. 29 (p. 24). This motion is certainly common to both components, and the system is therefore a physical one. My measures also seem to indicate direct orbital motion, the mean of four recent measures being:—

1903.62	73°.2	0″.20

as compared with:—

1902.64	61°.0	0″.19	4^{n}

β *80.*—This is one of the most interesting stars in Burnham's catalogue, and, at present, a very difficult pair to measure. The distance is rapidly diminishing, and data for an orbit will soon be available. My measures are:—

1901.88	9°.6	0″.32	2^{n}
1903.65	47 .2	0 .20	2

β 733 = 85 Pegasi.—The angular separation in this pair is still great enough to make the little companion easily visible under favorable conditions. Three recent measures give:—

1903.54 262°.0 0″.76

The computed position from BURNHAM'S orbit for the same date is: 267°.9, 0″.72.

September 10, 1903. R. G. AITKEN.

PERSONAL SCALE.

Dr. SCHLESINGER'S note on this subject in No. 91 of these *Publications* is of interest to all who are engaged in work involving the use of micrometer-screws. For the sake of comparison, I have thought it might be worth while to give here the results of a similar count I have made of the number of times each tenth was recorded in 1,200 recent readings of the micrometers attached to the 36-inch and 12-inch telescopes, together with the results of a similar count of 1,000 earlier readings. As the milled heads of the micrometer-screws are divided into one hundred parts, the tenths of divisions here considered have the value of thousandths of one revolution. The personal scale, therefore, does not affect the accuracy of the micrometer measures. In the following table all of the percentages would be 10.0 if there were no personal scale.

Tenths.	1200	1000
.0	20.2	20.3
.1	8.2	8.9
.2	16.7	15.7
.3	8.0	8.4
.4	6.8	7.8
.5	9.2	11.0
.6	5.9	6.7
.7	5.3	3.0
.8	15.3	14.6
.9	4.4	3.6

It is apparent that the two counts give practically the same error-curve, and show that while 0.5 was read as often as it occurred, 0.1, and especially 0.9, were slighted in favor of 0.0; and 0.3, 0.4, and 0.6, 0.7 in favor of 0.2 and 0.8 respectively.

September 8, 1903. R. G. AITKEN.

DISCOVERY OF A NEW COMPANION TO OΣ 499.

In the course of my survey of the stars in the zone + 56° to + 60°, I turned the 36-inch telescope upon OΣ 499 on the night of June 11, 1903, and found that the fainter star of this wide pair was a close double.

Three nights' measures of the new pair give:—

1903.54 146°.6 0".42 9.0-10.8 magnitudes.

The wide pair is probably fixed, having shown no motion since discovery in 1847.

September 10, 1903. R. G. AITKEN.

REDISCOVERY OF COMET 1889 V, 1896 VI (BROOKS).

The first observation of BROOKS'S Comet during the present apparition was secured with the 36-inch telescope on August 18th, $12^h\ 17^m\ 23^s$ Mt. Hamilton M. T., at which time it was found in R. A. $21^h\ 2^m\ 51^s.30$; Decl. — 27° 4' 18".8. The position predicted for this date by Professor NEUGEBAUER differs from the observed place by but little more than 5'. The comet is therefore following the predicted path very closely.

This comet is of unusual interest for several reasons. At the time of its first appearance, in 1889, it was attended by several companions, one of which at times rivaled its primary in brightness. It is also interesting because of its possible identity with the lost LEXELL'S comet, and because it is the only comet that has been observed at two consecutive oppositions, Professor BARNARD having secured five observations of it between November 22, 1890, and January 13, 1891,—a year and a half after its discovery.

On its second return to the Earth it was first observed by M. JAVELLE, at Nice, on June 20, 1896, and was followed by observers at fourteen stations until February 25, 1897, when Professor HUSSEY secured the last observation, with the 36-inch telescope.

Professor BAUSCHINGER determined the definitive elements from the observations in 1889-91, and later revised his work with the aid of the observations made in 1896-97. These elements, with corrections applied for perturbations, afforded the basis for the ephemeris which Professor NEUGEBAUER computed for the present apparition.

The companion comets were not observed in 1896-97, and no trace of them could be seen with the 36-inch this year.

It may be added that GIACOBINI's periodic comet (1896, V) has so far escaped detection on its present return, though it is favorably situated, according to theory, and has been carefully searched for with both the 12-inch and the 36-inch telescopes.

The two other periodic comets that are now in the neighborhood of the Sun, FAYE's well-known comet and PERRINE's comet (1896, VII), are very unfavorably placed, and the dense banks of smoke and haze that have hidden our horizon for some weeks have prevented any effective search for them.

September 22, 1903. R. G. AITKEN.

OBSERVATIONS OF THE WHITE SPOT ON *SATURN*.

The following observations of the white spot on *Saturn* were made with the 36-inch refractor, in the course of other work. No attempt was made to observe the spot systematically.

1903, July 17.—Spot transited planet's meridian at 23^h 31^m 15^s Gr. M. T. Equatorial diameter of spot (observed), $1''.25$; polar diameter of spot estimated to be two thirds of the equatorial diameter. Power, 520.

1903, August 23.—17^h 18^m Gr. M. T. Spot estimated to be $1''$ past the planet's meridian. The spot is larger and more conspicuous than on July 17th. The spot is divided by a very narrow dark east-and-west belt. C. D. P.

September 17, 1903.

VISUAL OBSERVATIONS OF THE SPECTRUM OF *NOVA GEMINORUM* MADE WITH THE 36-INCH REFRACTOR.

The spectrum of *Nova Geminorum* was observed visually with the one-prism spectrograph on the mornings of August 17th and 18th. The star was invisible in the finder, so that no estimate of magnitude could be made. Nothing could be made out either at H_α or D. The three chief nebular lines were, however, very well developed, that at $H\beta$ being faint, λ 4959 somewhat stronger, and that at λ 5007 very much more intense. There was probably also a very faint line visible near λ 4700, but too faint to identify with accuracy. The lines seemed sharp and well-defined. A plate of this region taken on April 6, 1903, (cf. *L. O. Bulletin,* No. 37,) showed a faint trace of the line at λ 5007, probably just beginning to appear. At present this line is far the most conspicuous, and in it is concentrated practically all the light of the visual spectrum. The change to the nebular type seems complete.

HEBER D. CURTIS.

PUBLICATIONS OF THE LICK OBSERVATORY, VOLUME VI.—MERIDIAN-CIRCLE.

This volume, which is now being sent out to the correspondents of the Lick Observatory, contains the results of Professor TUCKER's observations with the meridian-circle during the period August, 1896, to March, 1901. The observations include the following schemes of work: The Declinations of the Bethlehem Latitude Stars; Additional Standard Close Circumpolar Stars; Zodiacal Stars for Heliometer Measures of the Major Planets; The Southern Stars of the Catalogue of PIAZZI; The Reference Stars for the Photographs of *Eros;* and Miscellaneous Observations, including those of *Eros, Nova Persei,* comets, and comparison-stars.

CORRECTIONS TO ASTEROID EPHEMERIDES.

Asteroid observations made with the 12-inch equatorial give the following corrections to ephemerides published in *Veröffentlichungen des Rechen-Instituts,* No. 21:

(333)	*Badenia*	-25^s	$-3'.0$
(332)	*Siri*	$+60$	$+8.6$

JAMES D. MADDRILL.

GENERAL NOTES.

Some Common Inaccuracies in the Application of the Method of Least Squares.—It is gratifying to notice how wide-spread has become the use of the method of least squares during recent years. When the method was new it found favor only in astronomy and geodesy. Nowadays it is not only used in all kinds of physical problems, but one is no longer surprised to see it applied to problems in biology, in psychology, and even in sociology. Perhaps because of this wider field, or perhaps because of the pitfalls inherent to any branch of mathematical probability, it is certainly true that there are too many errors in current work of this kind. One might suppose that astronomers, with whom the subject is a century old, would be open in small degree to this criticism. But it appears that some are content to learn how to use the method without showing any great curiosity regarding the underlying principles. It may not be without value to point out some common inaccuracies and errors that the writer has noticed.

In a recent number of the *Astronomische Nachrichten* we read the following definition: "The probable error means that where no force is at work the result will probably differ from zero by just this amount." Evidently this is a recurrence of the time-honored confusion between probable error and "most probable error." The former is such that the chance for the real error exceeding it is just equal to the chance of the real error being less than it; or, otherwise stated, if p be the probable error of an observed quantity, m, then there is an even chance that the true value of m lies between

$$m - p \qquad \text{and} \qquad m + p$$

The "most probable" error is always zero, for this is only another way of stating a fundamental assumption, that large errors are less likely to occur than smaller ones.

It should be noticed that there is another definition of probable error,—namely, that implied in the expression

$$\pm 0.6745 \sqrt{\frac{[v\,v]}{n\,(n-1)}}$$

which is not quite identical with the former. The two approach equality only when n, the number of observations, becomes large. For example, if $n = 2$ the formula gives as the probable error of the mean about *one third* of $(m_2 - m_1)$, m_2 and m_1 being the two observations. It is easy to see, however, that the former definition leads to *one half* of $(m_2 - m_1)$ as the probable error. For we may have four cases, all equally likely to occur:—

(1) m_1 and m_2, each greater than the true value.
(2) m_1 greater, and m_2 less than the true value.
(3) m_2 greater, and m_1 less than the true value.
(4) m_1 and m_2, each less than the true value.

Consequently, there is just an even chance that the true value lies between

$$\frac{m_2 + m_1}{2} - \frac{m_2 - m_1}{2} \text{ and } \frac{m_2 + m_1}{2} + \frac{m_2 - m_1}{2}$$

According to the *former definition,* then, $\frac{m_2 - m_1}{2}$ must be the probable error of the mean.*

A misleading practice that one sees quite often is exemplified by the following. Suppose we have three determinations of a quantity with their probable errors:—

$$100 \pm 1$$
$$110 \pm 3$$
$$120 \pm 2$$

which we desire to combine into a final value. It is quite usual for the computer to obtain the weights from the indicated probable errors and to combine the three determinations accordingly into

$$104.5 \pm 0.86$$

This process ignores the existence of systematic errors (which in this case are so evidently present), and the result is open to criticism on two accounts: first, the adopted mean is not the best that can be gotten from the data; and, second, the probable error given is misleadingly small. Far more businesslike would it be to take the simple mean of the three determinations and to estimate the probable error at 4 or 5.

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*A rough but very convenient way of estimating the probable error of the mean of a small number of observations (not over five or six) is to divide twice the range by three times the number of observations. By the *range* we mean the difference between the greatest and the least of the observed quantities. This will usually give a sufficiently close approximation to the expression $0.6745\sqrt{\frac{[v\,v]}{n\,(n-1)}}$.

Another irritating practice is the loose employment of the word "uncertainty." Thus, one astronomer, after computing a probable error of 0".012, states that the quantity to which it is attached "is subject to an uncertainty of perhaps 0".02." It is doubtful whether this writer could say what he means by "uncertainty," and surely the word will convey nothing definite to his readers. This usage should be abandoned, at least until a precise definition is given to the word; and even then it would be inadvisable to use it, for we already have two errors in common use, the *mean* and the *probable*, to indicate the reliability of a quantity. It would be convenient if one of these two could be employed to the exclusion of the other, for now it is necessary to specify which is being used in each particular case. German astronomers lean toward the mean error, and Americans toward the probable. The former obviates the necessity of multiplying by 0.6745; but this small advantage is outweighed, in our opinion, by the fact that the probable error has a concrete definition. Any person of fair intelligence can understand what probable errors are, even though he knows little of mathematics. The mean error, on the other hand, has an exceedingly technical definition. However, if one of these errors could be universally adopted, it would be a matter of small importance which should prevail.

Probably owing to the example set by GAUSS, it was formerly usual to give probable and mean errors to four or five significant figures. This practice has greatly decreased, but it has not entirely disappeared. In many cases two figures are ample, and it is difficult to imagine a case where more than three could be defended.

An error more serious than any of the above came under the writer's notice some time ago, and since then he has seen several other examples of it. The principle involved does not seem to be referred to in any of the standard works on the subject. Suppose we have a number of observation equations (equations of condition) involving several unknowns. Let these be solved by the method of least squares, and the resulting values of the unknowns be substituted in the original observation equations, giving the residuals in the usual way. Now, considering each of the residuals in turn, it may be small for either of two reasons: first, because the corresponding observation was an accurate one; or, second, because of the way in which the coefficients of the unknown quantities enter. For example, if one of the unknowns rests for its determination principally upon only one of the observation-equations, then the residual for that equation will inevitably be small. The error to which the writer wishes to call attention results from the neglect of the possibility of a residual being small for any other reason than that the observation was an accurate one. A numerical example will make this clearer. We will suppose that we desire to find the declination (δ_0) at 1830 and the proper motion (μ) of a star which has been observed in 1800, 1830, 1840, and 1850. Assuming as a first approximation that all four observations are equally good, we solve by the method of least squares and compute the residuals:—

$$\begin{aligned} v_1 &= \delta_0 - 30\mu - \delta_1 \\ v_2 &= \delta_0 \qquad\;\; - \delta_2 \\ v_3 &= \delta_0 + 10\mu - \delta_3 \\ v_4 &= \delta_0 + 20\mu - \delta_4 \end{aligned}$$

Suppose similar computations have been made for many other stars observed at the same dates, and that it is found that the average residual for the observations made in 1800 is about equal to the average residual for any of the three other dates. It would be a gross error to conclude from this that the observations made in 1800 are equally accurate with the others (yet just this has been done by some astronomers), because the proper motions depend so largely on the earliest observation that, other things being equal, we are bound to get small residuals for that date. It is not the writer's intention to go into the details of this point in this place. It will suffice to say that it is possible to compute the ratio between the actual errors of observation and the residuals, for any given set of equations. In the example above, these are respectively for the four equations, 0.11, 0.75, 0.68, and 0.46. If the residuals came out on the average proportionate to these ratios, then only could we conclude that the observations were of equal weight.

One other kind of error deserves mention before closing this note. In writing down our equations of condition we should be careful to let the measured quantities appear just as we observe them. Thus, suppose we desire to find x and y from equations of the form

$$x + n_1 y = m_1$$
$$x + n_2 y = m_2$$
etc., etc.

These equations are evidently equivalent to

$$y + a_1 x = b_1$$
$$y + a_2 x = b_2$$
etc., etc.,

where $n_1 = \frac{1}{a_1}$, $n_2 = \frac{1}{a_2}$, etc.; and $m_1 = \frac{b_1}{a_1}$, $m_2 = \frac{b_2}{a_2}$, etc. In general, these two sets of equations, if solved by the method of least squares, will give two different values for x and two for y. The first set should be used if m_1, m_2 were observed, and the second set if b_1, b_2 were observed. Other examples can be constructed in which the fallacy is not quite so apparent as in the above. For an actual case the reader is referred to *Nature* (Vol. 63, page 489). FRANK SCHLESINGER.

Example of Personal Scale.—In connection with the note which appeared in the last number of these *Publications,* Mr. J. A. PARKHURST has kindly communicated the results of two counts: (1) of 1022 readings of a photometer scale; and (2) of 1148 readings of a micrometer. The first column below gives the estimated tenth; the other columns are percentages of the whole:—

	First Count. (Per cent.)	Second Count. (Per cent.)	Mean. (Per cent.)
0	17.5	14.0	15.7
1	7.1	10.3	8.7
2	12.0	11.9	12.0
3	9.7	9.4	9.6
4	6.2	5.3	5.8
5	7.4	8.1	7.8
6	4.5	6.4	5.4
7	11.3	9.8	10.5
8	16.9	13.0	14.9
9	7.4	11.8	9.6

This observer's scale is well pronounced and very symmetrical, the only exception in the latter respect being that 8's are preferred to 2's. F. S.

During 1903 four doctorates in astronomy were granted by universities in this country. This is equal to the average for the five preceding years. The recipients of these four degrees and the titles of their theses are: W. A. HAMILTON (University of Chicago), *On the Convergency of the Series in the Determination of the Elements of Parabolic Orbits and the Errors Introduced in the Elements by Imperfections of the Observations;* H. K. PALMER (University of California), *An Application of the Crossley Reflector of the Lick Observatory to the Study of Very Faint Spectra;* JOEL STEBBINS (University of California), *The Spectrum of o Ceti;* J. P. McCALLIE (University of Virginia), *A Problem in Periodic Orbits, Second Order Perturbations of Jupiter and Saturn, Independent of the Eccentricities and of the Inclinations.*

From various sources, principally *Science,* we gather the following items: Dr. BURT L. NEWKIRK, a graduate ('97) of the University of Minnesota, has been appointed a computer on the orbits of the Watson asteroids at the University of California. Doctor NEWKIRK obtained his Ph.D. last year at Munich, his thesis being a photographic determination of the parallax of the central star in the annular nebula in *Lyra.*——Dr. CHARLES S. HOWE, Professor of Astronomy at the Case School of Applied Science, has been appointed president of that institution.——Professor E. C. PICKERING and Sir WILLIAM HUGGINS are among those who received honorary doctorates at the recent celebration at the University of Heidelberg.——Mr. ARTHUR R. HINKS, well known for his work in astronomical photography, has been promoted to the chief observership at Cambridge Observatory, England, in the room of Mr. GRAHAM, who has retired at an advanced age. Mr. W. E. HARTLEY has been appointed to the post made vacant by Mr. HINK's promotion.——M. LEBOEUF has been appointed Professor of Astronomy at the University of Besançon.——Professors H. H. TURNER (of Oxford) and W. KAPTEYN (of Utrecht) have accepted invitations to visit this country as representatives of astronomy at the congress which is to be held at the St. Louis Fair. Among the mathematicians who have accepted similar invitations is POINCARÉ.——H. L. SMITH, Professor of Astronomy and Physics in Hobart College, died on August 1st.

PROSPER HENRY, astronomer *adjoint* at the Paris Observatory, died on July 25th, at Pomogen in the French Alps, as a result of exposure to extreme cold. The two brothers, PROSPER and PAUL, have been connected with the Paris Observatory for nearly forty years, and have taken a great part in the recent work of that institution. It is said that there is not an instrument in the observatory that the HENRYS have not made or remodeled. Very rarely has one of the brothers published anything apart from the other, and their work is so interwoven that probably no one knows just what is due to the one and what to the other. An illustration of this will be found in their discoveries of minor planets. The first of these is credited to PROSPER, the next to PAUL, the next to PROSPER, and so on through the whole fourteen. The HENRYS will no doubt be remembered longest for the share they took in bringing about the Astrophotographic Catalogue. Their other important work consists in the making of lenses and plane mirrors, asteroid discoveries, discovery of nebulæ in the *Pleiades*, method for reducing photographic star positions, and many other researches in astronomical photography. F. S.

On May 2, 1903, ground was broken for the erection of a new observatory at Amherst College. The plans contemplate a structure one hundred and fifty feet long, east and west, surmounted by three domes, the central one to contain an equatorial refractor with a lens eighteen inches in diameter. This telescope is now in the process of construction by the Alvan Clark & Sons Corporation.

Number III of volume XLVIII of the Annals of Harvard College Observatory, containing a Provisional Catalogue of Variable Stars, forms a very welcome addition to variable-star literature. The last preceding catalogue, CHANDLER'S third, was published in 1896, and, as the number of variable stars has increased largely since that time, it had become impossible, unless one kept up a card catalogue, to keep properly informed of the advances in this work.

SCHÖNFELD'S first catalogue (1865) contains 113 stars;

Chandler's third catalogue (1896), 393 stars; while in the present catalogue 1,227 stars are included, 509 of which, however, are the variables discovered by Professor Bailey in clusters. In constructing this catalogue Professor Pickering has departed from the guiding precepts used for other catalogues, and has included many stars whose variability has not yet been confirmed, claiming that it is better to include some stars not variable (definite names having not yet been assigned) than to exclude some which are variable. This position is certainly correct, especially for a provisional catalogue. One of the chief uses of a variable-star catalogue is to guide the observer in making up the observing list. It should therefore contain, in my opinion, not only a list of the certainly recognized variables, but a list, preferably, supplementary, of all stars ever suspected of variability, even though observations may have shown that for a considerable length of time the star was constant in light.

A new form of designation has been introduced into the catalogue, consisting of six figures which give the approximate position of the star. The first two figures are those of the hour, and the next two those of the minutes of Right Ascension of the star for 1900. The last two figures give the degree of Declination. South Declination is indicated by printing the figures in italics. The designation of the first star of the catalogue is *000339*, which means R. A. $0^h\ 3^m$, Dec. — 39°. In defense of this system Professor Pickering states as follows: "A new form of notation is proposed with much hesitation, but it has been found so convenient in actual use here that it has been retained. It aims to furnish a distinctive designation for any star, which will not be too long to be readily retained in the memory, and yet will give the position with sufficient precision to give the approximate setting for a visual or photographic telescope, or to decide whether the object is conveniently situated for observation."

It might be stated, however: *First.* It is not at all certain that six figures can be readily retained in the memory for any considerable length of time,—for instance, while one is making observations of the variable. I believe it will be generally admitted that the average person of astronomical training will retain four figures without effort. But when the number of figures reaches six, I believe that, in general, a distinct mental effort will be necessary to retain them. Any one accustomed to using logarithms knows how much more mental effort is required in using six-place tables than in using four-place tables, although of course considerable of this added effort comes in making the interpolations.

Second. If the observer is working with a telescope larger than four inches, he will desire for setting purposes a declination more accurate than the nearest degree.

Third. It will be necessary for the observer in recording observations to adopt some symbol to denote South Declination. This will require added effort, and the omission of the symbol may lead to confusion between north and south stars. It should be stated, however, that this last is a theoretical rather than a practical objection, for in the catalogue under consideration there are only two instances of two stars, one north and one south, having the same designation.

Fourth. It will very seldom happen that one will have at hand the designation of the variable and not its coordinates also; and if one wishes to see whether or not the star is in position for observation, it will be more convenient to refer to the columns of Right Ascension and Declination than to the designation-number.

Fifth. Although good for a great many years, the position given in the designation-number, because referred to the epoch of 1900, would ultimately not be sufficiently exact for setting purposes. Our successors of the twenty-first and following centuries may get tired of referring to the epoch of 1900.

CHANDLER's system of designating variable stars has been pretty generally adopted, and should be retained, I believe, until one is proposed which is distinctly and unmistakably better.

The new catalogue contains two columns not found in CHANDLER's catalogues. The one gives the class to which the variable belongs, the classification being that proposed by Professor PICKERING in 1880; the other designates the spectrum of the variable, the notation employed being the same as that used in the DRAPER catalogue.

Copious notes and several supplementary tables follow the catalogue.

An examination of this catalogue reveals the vast amount of work that variable-star observers have before them. Some of the columns are conspicuous for their incompleteness. There are listed in the catalogue, excluding new stars and variables in clusters, 286 stars whose periods are only approximately known or wholly unknown.

S. D. T.

PUBLICATIONEN DES ASTROPHYSIKALISCHEN OBSERVATORIUMS KÖNIGSTUHL-HEIDELBERG, HERAUSGEGEBEN VON DR. MAX WOLF. ERSTER BAND. KARLSRUHE, G. BRAUN. 1902.

This interesting volume is the first of the publications of this observatory under its new régime. Wisely limiting itself to one chosen field, the observatory has produced a volume which entitles it to a high rank as an institution of definitely concentrated research. A full description of the buildings and instruments is left for a subsequent volume. Provided as it is with two Voigtländer 6-inch cameras and the two great 16-inch Bruce photographic lenses, the Königstuhl Observatory is singularly well equipped for stellar and planetary photography. It is unnecessary here to mention Dr. WOLF's successful work on the asteroids.

As a field in which comparatively little has been done, the Königstuhl Observatory has fixed upon the photography and accurate cataloguing of nebulæ as its main work, and it is to this subject that the present volume is largely devoted. A rapid and accurate method was needed to measure the positions of the large number of small nebulæ discovered photographically, and a parallactic measuring-engine on the lines proposed by KAPTEYN was procured. In connection with the First Königstuhl List of 154 Nebulæ, a description of the instrument is given by Dr. WOLF, with an investigation of the errors of the screws and circles. The method of the parallactic measuring-engine is, in brief, as follows: Let us suppose the measuring-microscope to be mounted as a small equatorial and the photographic plate to be placed at a distance from it equal to the focal length of the lens with which it was taken. Then, if the photographic plate is placed in a position which, as seen from the little measuring-equatorial, is of the same hour-angle and declination as was the region of the sky at the time of the exposure, we can with the equatorially-mounted microscope read off the positions of objects directly in differences of Right Ascension and Declination, much as would be done with an equatorially-mounted telescope fitted with a filar micrometer. In practice the equatorially-mounted microscope is placed with its polar axis horizontal, and is provided with a third vertical axis for convenience.

Dr. SCHWASSMAN, after treating very fully the theory of the apparatus, has used it in the preparation of the Second Königstuhl List of 301 Nebulæ, employing the full and rigorous methods demanded by the theory in the case of plates of large area. This second list contains the positions for 1900 of 301 nebulæ in *Virgo.* The employment of the full formulæ must have consumed a very great deal of time in both measurement and reduction, and such refinement would seem entirely unnecessary in objects of the definition of an ordinary nebular patch, and in plates of this area, where the images of ninth-magnitude stars are about 47″ in diameter. Dr. SCHWASSMAN finds for the mean error of a position

$$m_\alpha = \pm 0^s.16 \qquad m_\delta = \pm 1''.8$$

and a comparison with micrometer results shows that the accuracy of the coordinates in Right Ascension is of the same order of magnitude as that of direct micrometer measures, while the accuracy in Declination is slightly inferior.

In a later paper in the same volume Dr. WOLF gives the Third Königstuhl List of Nebulæ, comprising 1,528 nebulæ near the pole of the Milky Way. By using more approximate methods, and neglecting the full and rigorous formulæ of KAPTEYN's method, a great saving of time was effected without appreciable loss of accuracy. Dr. WOLF estimates the error of a position in the third list as somewhat larger than $0^s.1$ and $1''.0$. As to the time consumed, about eighty-two hours were spent in the actual measurement, so that the positions of 1,528 nebulæ to the above degree of accuracy were secured in a few weeks, whereas had the full and rigorous method employed by Dr. SCHWASSMAN been used it would have been several years. Of these 1,528 nebulæ only one in nineteen, or about five per cent, were previously known, confirming KEELER'S conclusions (*Astrophysical Journal,* vol. XI, p. 325) as to the enormous number of these small objects. A map is given showing the density of the grouping of these nebulæ about the pole of the Milky Way, and Dr. WOLF states that he knows of no other region where nebulæ are so thickly clustered, there being at the densest portion no fewer than seventy in one sixteenth of a square degree. Another point of interest brought out in this investigation is, that the large majority of the position-angles of the axes of "long" nebulæ are grouped about 60°.

Dr. CARNERA investigates the light-curve of the variable star *S Leonis* by photographic methods. The method used was that of the measurement of the diameters of the star-disks on the photographic plates. Numerous precautions were taken to avoid the errors which may so easily arise in this method, and plates were taken of the region of the variable, the *Pleiades,* and the Pole at the same angle of elevation above the horizon. CHANDLER'S period and light-curve is confirmed. Dr. CARNERA gives also a number of photographic positions of *Eros.*

Mr. A. KOPFF, in an interesting paper, gives an investigation from the negatives of two regions of the phenomenon, first noted by HERSCHEL, that the regions about many nebulæ are relatively starless. The regions investigated are those about the Nebula in *Orion* and the great "America" Nebula. A count of the stars was made, showing that each of these is surrounded by a veritable star-desert, the *Orion* Nebula lying near the northwest and the America Nebula near the northeast end of the relatively starless tracts surrounding them.

H. D. C.

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NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.
(February, April, June, August, October, December.)

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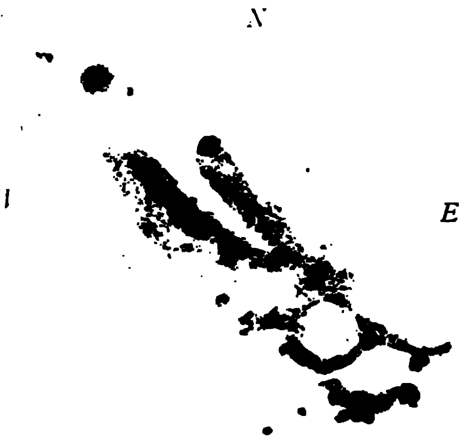
THE GREAT SUNSPOT OF OCTOBER, 1903.

By ROSE O'HALLORAN.

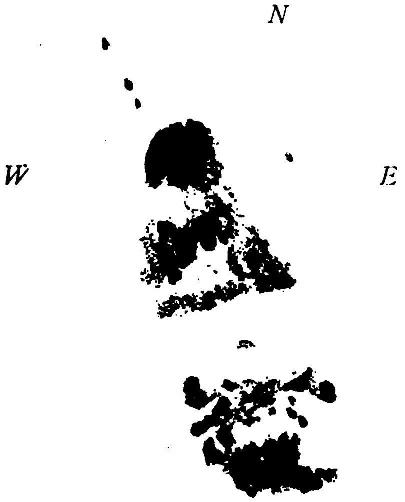
The recent sunspot cycle has been of unusual duration, though, according to data revised by Professor A. WOLFER, not beyond the limit of variations previously noted. Twelve and a half years elapsed between the extreme of the minimum, in the winter of 1890 and that of September, 1902, when it became evident to telescopic observers of the solar surface that a slow but steady increase of spottedness had commenced; while the incoming maximum of the summer of 1891 antedates by twelve and one quarter years the corresponding stage so conspicuous in October last. Not since September, 1898, has such an enormous formation discolored the white surface of the Sun.

In a four-inch telescope it was first visible on the morning of October 5th, while the easterly umbra was still in contact with the limb, and the branching penumbra was seen at parallel lines slanting in a northeast direction. A daily record of the condition of the solar surface shows that the tract was unspotted during the preceding rotation.



Large Sunspot, Oct 8, 1903, 9 A. M.
(Screen Image.)

On October 6th seven distinct umbræ were noticeable, which were increased to eleven on the day following, and on the 8th at least sixteen were strewn over the treelike penumbra. Having then emerged from the atmospheric haze of the solar limb, it was clearly visible without magnifying power, and when midway across the disk the main unbroken section measured about 130,000 miles, with an average width of 30,000. The central part extended in south heliographic latitude thirty-five degrees, its slow journey of nearly fourteen days from limb to limb also corresponding with this distance from the solar equator. Changes continued from day to day, and its largest midway phase, on October 11th, was altered in general outline, some nuclei having united, others having divided, while the encircling penumbra was more compact, though still mingled with clear photospheric areas. Then some mighty force gained sway in the region during the night, and when the 12th dawned the vast penumbra was rent crosswise in nearly equal parts. The intervening field of photospheric matter, about 30,000 miles in width was rhomboidal in form, with remarkably even angles, only one penumbral remnant, like an islet in a channel, surviving the swift symmetrical severance. As the formation advanced in the west quadrant, a decrease in the number of nuclei and a general decline were noticeable, but the wide rift was still apparent until the 16th, when the foremost section had disappeared at the west limb. On the 17th the remaining part was still distinctly seen, and about fifteen degrees in the rear was a new addition, a small faint spot, destined to be conspicuous in the succeeding rotation. On the morning following the large sections had passed from



Large Sunspot, Oct. 12, 1903, noon.
(Screen Image.)

view. In due time, twenty-seven days from its first appearance, a field of faculæ and a slight irregularity in the contour of the limb was discernible far to the south. This was on the 1st of November, 10:30 A.M. At noon the penumbra was visible, and at 4 P.M. the foremost umbra as a faint dark line. As the two sections advanced, they were seen to be much decreased in size and changed in form, but several degrees in the rear was a large scattered group, probably a development from the small spot above mentioned. When central in the southerly zones, this addition was about 70,000 miles in length, and made the group again visible to the unaided eye on clear days. Even more distinct was a conspicuous group with large umbræ in north latitude 15° that had appeared on the east limb on the 29th of October, while near the southwest limb was a rather large group that had come in on the 25th of the same month.

Though larger spots have been seen than any one of these three, the extent of spotted area at one time has not been equaled since 1894.

PLANETARY PHENOMENA FOR JANUARY AND FEBRUARY, 1904.

By Malcolm McNeill.

PHASES OF THE MOON, PACIFIC TIME.

Full Moon,	Jan.	2,	9^h 47^m P.M.	Full Moon,	Feb.	1,	8^h 33^m A.M.
Last Quarter,	"	9,	1 10 P.M.	Last Quarter,	"	8,	1 56 A.M.
New Moon,	"	17,	7 47 A.M.	New Moon,	"	16,	3 5 A.M.
First Quarter,	"	25,	12 41 P.M.	First Quarter,	"	24,	3 9 A.M.

The year 1904 is a leap-year, the first since 1896, and the regular succession of leap-years every fourth year will not be interrupted until the year 2100.

The Earth is in perihelion January 2d, 8 P.M., Pacific time.

Mercury is an evening star at the beginning of January, having reached its greatest east elongation, 19° 30′, just before midnight on December 31st. The elongation is not a very large one, as the planet passes perihelion only a few days later, on January 10th, but it remains above the horizon for an hour and

NOTICES FROM THE LICK OBSERVATORY.[*]

PREPARED BY MEMBERS OF THE STAFF.

NEW DOUBLE STARS.

The continuation of my systematic search for new double stars has resulted in the discovery of about two hundred additional pairs, bringing the total number so far found up to about six hundred and thirty. The positions of all these new pairs, with detailed measures, will soon be published in the *Lick Observatory Bulletins.*

I wish here to call attention to only a few of them which seem to be of special interest. The positions are for 1900.0.

R. A., $2^h\ 54^m\ 46^s$; Decl., —9° 49′.

A and B.

1903.80	309°.8	3″.64	8.1-13.5	3^n

A and C = h 3545.

1903.79	66°.8	43″.86	8.0- 9.0	1^n

The wide Herschel pair is of no interest as a double star; the new companion is too faint to measure with the 12-inch telescope.

R. A., $3^h\ 51^m\ 20^s$; Decl., —7° 14′.

A and B.

1903.80	289°.1	0″.32	9.0- 9.2	3^n

AB and C = β 542.

1903.80	190°.6	1″.56	8.6- 9.5	3^n

The β pair shows no evidence of motion, BURNHAM'S measures with the 36-inch in 1892 giving 192°.5 and 1″.50. But if the new pair had been as easy at that time as it is now, it could not have escaped detection. The probability therefore is, that it is a binary in fairly rapid motion.

---

[*] Lick Astronomical Department of the University of California.

R. A., $8^{h}\ 1^{m}\ 37^{s}$; Decl., —8° 57′.

B and C.

1903.82	324°.8	1″.17	8.5-12.0	1^{n}

A and B = Σ 1183.

1903.82	326°.8	30″.48	6.0- 8.5	1^{n}

The wide Struve pair is fixed. The new companion is not a difficult object, and should have been seen before, unless the distance has been less than at present. There are several other faint stars within 30″ of B.

R. A., $4^{h}\ 55^{m}\ 41^{s}$; Decl., +28° 9′.

1903.84	317°.3	0″.48	8.0-12.0	2^{n}

R. A., $4^{h}\ 59^{m}\ 24^{s}$; Decl., —6° 10′.

1903.83	357°.0	0″.24	7.0- 8.0	4^{n}

R. A., $5^{h}\ 38^{m}\ 2^{s}$; Decl., —6° 51′.

1903.80	121°.4	0″.14	6.9- 7.8	4^{n}

R. A., $21^{h}\ 16^{m}\ 29^{s}$; Decl., +9° 55′.

1903.84	272°.5	0″.18	7.0- 7.0	3^{n}

R. A., $21^{h}\ 50^{m}\ 32^{s}$; Decl., +43° 35′.

1903.68	247°.3	0″.20	8.0- 8.1	3^{n}

These five pairs well illustrate the efficiency of the large telescope for this class of work. Under good conditions the 36-inch shows them all so distinctly that good measures can be made without special difficulty. The first pair is the most difficult one, and it is doubtful whether it could be measured with a much smaller aperture. The fifth pair was noted as "double?" with the 12-inch. The fourth pair forms the 6.5-magnitude star 7^{m} following and 20′ north of δ *Equulei* and belongs, as do also the second and third pairs, to the class of double stars in which we expect to find rapid orbital motion.

That not all the new pairs are so difficult is shown by the following example, which would be an easy pair for a good six-inch telescope:—

R. A., $2^{h}\ 37^{m}\ 56^{s}$; Decl., —6° 55′.

1903.75	110°.8	1″.50	8.4- 8.5	3^{n}

November 12th, 1903.

R. G. AITKEN.

THE D. O. MILLS EXPEDITION TO CHILE.

The installation of the D. O. Mills Expedition to the Southern Hemisphere was no doubt completed in October. The observatory is erected on the summit of San Cristobal, in the northeast suburbs of Santiago. Its elevation above the city is about 950 feet, the altitude of Santiago above sea-level being 1,800 feet. The buildings, dome, reflecting telescope, spectroscope, etc., were in place early in September, and the latest mail advices stated that the electric line to supply current for maintaining the spectroscope at a constant temperature was under construction. The length of the line from the summit to the electric plant at the base of the hill is one kilometer.

The expedition reached Chile just at the breaking out of a series of labor troubles. This and the storms of winter made the construction of the observatory one of considerable difficulty. At the time of last writing, October 9th, Astronomer WRIGHT, in charge, reported that spectrograms had been secured for determining the velocities of twenty or more stars.

It is expected that a full account of the expedition, accompanied by illustrations of buildings and instruments, will be available for publication in the near future. W. W. C.

THE NEW VARIABLE, 59.1903 *CYGNI.*

The new variable in *Cygnus*, first announced by WOLF as a *nova*, and later identified as DM + 37°.3876 by BARNARD, was observed here with the 12-inch equatorial telescope for magnitude and position on October 5th. Comparison was made both with photometer and micrometer with the Lund A. G. star 9237 ($8^m.9$). Applying the necessary correction of — 1′ to the catalogued Declination of this star (announced by Professor H. A. HOWE, in *A. J.* 548), the resulting position is:—

α 1903.0, $20^h\ 14^m\ 57^s.01$ δ 1903.0, $+37°\ 08'\ 47''.5$

The magnitude observations were made with the wedge photometer designed by Professor E. C. PICKERING for the determination of faint stellar magnitudes. The wedge constant and the absorption of the shade-glasses have not yet been accurately determined. The provisional values used, however, are perhaps not more than ten per cent in error. Following are the observed magnitudes:—

G. M. T.	
Oct. 5^d.72	10^m.2
12 .84	10 .5
16 .81	10 .8
22 .75	10 .5
Nov. 6 .76	10 .6

Nov. 23, 1903. James D. Maddrill.

Visitor to the Lick Observatory.

Professor C. Michie Smith, Director of the Kodaikanal Observatory, India, visited Mt. Hamilton in November. The Kodaikanal Observatory has been under construction for several years past, and the equipment is nearing completion. It is located on the summit of one of the principal peaks in the Palani Hills, in the Madras Presidency, at an elevation of 7.700 feet. Director Smith's plans are to limit the work almost wholly to the study of the Sun.

Professor Smith is also in charge of the Madras Observatory, now devoted largely to the meteorological and time services, the climate of Madras not being favorable for astronomical investigation. His visit to the Lick Observatory was a source of pleasure to all the members of the staff.

W. W. C.

GENERAL NOTES.

The Longitude of Honolulu.—Mr. JOHN F. HAYFORD presented to the Philosophical Society of Washington on October 10, 1903, an account of the various determinations of the longitude of Honolulu that have been made since 1555. Assuming as correct the recent determination by the telegraphic method of the difference of longitude of San Francisco and Honolulu, which gives the position of the Transit of *Venus* pier at Honolulu as $10^h\ 31^m\ 27^s.24$ west of Greenwich, Mr. HAYFORD gives a table showing the errors of earlier determinations. It is very interesting to note that as early as 1785 Captain COOK determined the longitude within 18^s, or 4½ miles,—a high degree of accuracy when the poor construction of the chronometers of that day is taken into account,—while Captain FREYCINET in 1819 obtained a result that differs only 1^s, or about one quarter of a mile, from the most recent determination. All the maps of the Hawaiian Government Survey since 1874 are based on the longitude determined by Captain TUPMAN from observations of meridional transits of the Moon, occultations of stars, and zenith-distances of the Moon's upper and lower limbs, combined with those of well-known stars near the Moon. This value is $10^h\ 31^m\ 27^s.2$, agreeing with the new determination to the nearest tenth of a second.

The Planet Mars.—Additional contributions to the extensive literature on the canals of *Mars* are made by Messrs. E. M. ANTONIADI and E. W. MAUNDER in the November number of *Knowledge*. Instead of giving us new markings and canals, it is rather the object of these gentlemen to explain away some that now mark the maps of *Mars*. M. ANTONIADI's conclusion seems to be that the so-called canals are not a simple phenomenon, either objective or subjective. It is his belief that these markings are, in part at least, real, but in greater part are due to physiological causes. In a letter to the *English Mechanic*, quoted by Mr. MAUNDER, M. ANTONIADI sums up the 'canal-impression' under five heads:—

"(*a*) Entirely physiological markings, like those seen by Mr. LOWELL on other planets, by myself on *Mars*, and by Mr. LANE on his artificial disks.

"(*b*) Subjective lines, generated by the topographical details.

"(*c*) Edges of physiological half-tones, begotten by contrast.

"(*d*) Edges of objective half-tones, arising from the same reason; and

"(*c*) Incontestably real canals, which, were we to see *Mars* better, would resolve themselves into groups of knotted or unevenly shaded areas."

Mr. MAUNDER describes in some detail, and with illustrations, the results of experiments made by him with a class of twenty boys, about twelve to fourteen years old, who were seated in four or five rows at different distances from a carefully lighted diagram, which they were told to copy. The diagram was reproduced from some published drawing of *Mars*, but in nearly every experiment the canals were omitted. In general, any boy was used in only one experiment, though a few drew the same diagram twice, at different distances.

"The general result was striking. In several of these experiments nearly all the boys drew 'canals' on their copies, though there were none on the orginal from which they were copying. And these 'canals' were not placed at random; they were in just the very places where canals are seen in the charts of SCHIAPARELLI and LOWELL."

We cannot quote at greater length from this interesting article, but must refer our readers to the original. We may add that, as Mr. MAUNDER says, "the most interesting feature with regard to the entire discussion is the tendency of the ablest and most favorably circumstanced observers to see the chief canals no longer as straight uniform lines, but as close sequences of spots, as if an approach had been made to their complete resolution."

A stained-glass window, to commemorate the long connection of Dr. JOHN P. NICHOL, Professor of Astronomy, and his family with the University of Glasgow, has been placed in the Bute Hall of the college. At the top of the new window appears URANIA, the heavenly muse. In the smaller lights around her are various objects familiar to astronomers. The four figures in the top division of the window represent COPERNICUS, GALILEO, KEPLER, and NEWTON, the four great founders of modern astronomy. The late professor wrote numerous and delightful books on "The Solar System," "The Planetary System," and "The Architecture of the Heavens," and these works stimulated throughout the English-speaking world an extraordinary interest in the subject. ANDREW GRIEG.

Those who are interested in the question whether long-period weather forecasting will ever become practicable will find in *Science* for November 13, 1903, an interesting article by Sir NORMAN LOCKYER, entitled "Simultaneous Solar and Terrestrial Changes." The paper is really a concise historical account of the progress made in the study of such solar phenomena as the periodicity of the spots and the distribution of the prominences, and of the influence of such solar disturbances upon magnetic and meteorological conditions on the Earth.

From *Science* we learn that the new observatory of Amherst College has been so far completed that regular observations are in progress. The sum of $100,000 has been raised for building purposes and for endowment.

Another new observatory that is well equipped for research as well as for instruction is the Washburn College Observatory, Topeka, Kansas, which was dedicated on September 18, 1903, Professor C. L. DOOLITTLE, of the Flower Observatory, delivering the address. The equipment includes an 11½-inch refractor and a 5-inch photographic doublet, as well as a number of smaller instruments. It is designed to add other instruments (in particular, a meridian-circle and a spectroscopic outfit) and a working astronomical library.

Professor DOOLITTLE's address, just mentioned, is published in full in the November number of *Popular Astronomy*. It is entitled "Some Observatories and Observers, Past and Present," and gives an interesting account of the incidents and efforts that led to the establishment of some of the best-known observatories in Europe as well as of the development of astronomy in this country.

Autobiography of Professor SIMON NEWCOMB.—Under the title "The Reminiscences of an Astronomer," HOUGHTON, MIFFLIN & CO. have recently published an autobiography of the able and well-known astronomer, Professor SIMON NEWCOMB. This volume, modestly relating the chief events in the life of one who has been extremely influential in promoting American astronomy, makes very interesting reading. W. W. C.

PUBLICATIONS OF THE LICK OBSERVATORY, VOLUME VI.

Volume VI of the *Publications of the Lick Observatory* is a substantial book of 405 pages, containing the work of Professor RICHARD H. TUCKER with the Repsold meridian-circle from August, 1896, to March, 1901. Four thousand five hundred stars have been observed, 11,700 complete observations of both Right Ascension and Declination having been made, and 2,700 other determinations of one of these coordinates only. That so large an amount of high-class work has been done by a single observer in a time so short is exceedingly creditable to the Lick Observatory and to the astronomer who made the observations.

There are six main divisions of the volume, and we shall review each separately.

THE DECLINATIONS OF THE BETHLEHEM LATITUDE STARS.

The most extensive series of observations for the determination of variation of latitude ever made in this country is that executed by Professor C. L. DOOLITTLE at South Bethlehem, Pa. It is evidently a matter of importance that the declinations of Professor DOOLITTLE'S stars should be known with considerable accuracy, and should be reduced to some standard system. Professor TUCKER'S observations have been planned with a view of accomplishing this reduction by means of observations of the stars in conjunction with suitable fundamental stars.

The average number of fundamental stars observed each night was more than one fourth of the total number observed on that evening. The working list of stars used in the South Bethlehem observations originally contained 347 stars, and three were added afterwards; two of these were not observed. The general plan was to observe each star four times, the instrument being reversed for the second pair of observations. It was Professor DOOLITTLE'S original intention to use the system of Boss for all the stars. Professor TUCKER has reduced every star to this system, and has compared with the system of AUWERS.

There were 68 stars common to Boss's "Declination of Fixed Stars," and the *Berliner Jahrbuch*. By comparing the declinations of these Professor TUCKER has derived the following formula:—

$$\text{Boss-B. J.} = -0''.10 + 0''.002\ \delta^\circ$$

A comparison of the two systems was also effected in another way. For each of 120 stars the Declination was observed. The result thus obtained was compared with that given by Boss, and also with that of the *Berliner Jahrbuch.* Thus resulted the following formula:—

$$\text{Boss-B. J.} = -0''.08 + 0''.001\ \delta^\circ$$

The agreement of these two formulas is striking, and shows the accuracy of the observations. It also appeared from this investigation that the probable error of a *B. J.* declination is $\pm\, 0''.24$.

The conclusion reached as to the systematic errors of the observations is, that those due to flexure, bisection, and the difference U. C.–L. C. are practically negligible.

By discussing the probable error of an observed declination, the following results were reached:—

Probable-error observation,	$\pm\, 0''.09$,	mean of four.
Probable-error graduation,	$\pm\, 0''.08$,	two positions.
Probable-error fundamentals,	$\pm\, 0''.08$,	group of twelve.
Total probable error,	$\pm\, 0''.15$.	

These figures speak eloquently of the accuracy of the work.

From each observation of a fundamental star combined with the nadir-reading (taken three times each full night) a value of the latitude was obtained. After applying the corrections for variation of latitude computed from CHANDLER'S elements, and combining the observations by pairs in such a way as to eliminate the division error of the nadir-reading, the following value of the normal latitude was reached:—

$$\phi_0 = 37^\circ\ 20'\ 25''.42\ (\pm\ 0''.03)$$

The star-places originally derived by Professor DOOLITTLE were taken directly from Boss, or reduced to that system, or occasionally adopted from some other authorities. Professor TUCKER finds that the probable error of one of these declinations is $\pm\, 0''.4$. It is evident that wisely directed and accurate observation with a modern meridian-circle has given results superior to those obtained by a careful discussion of material previously obtainable.

ADDITIONAL STANDARD CLOSE CIRCUMPOLAR STARS.

These stars, twenty-one in number, all lie above 82° of North Declination, and half of them are above 85°. They were observed at the request of Dr. AUWERS. The mean places for each year of the interval 1895-1905 have been published in *A. N.* 3440. If ephemerides giving the apparent places of these stars could be issued from year to year, or to cover periods of five years, they would be very useful to all observers who have occasion to make determinations of azimuth. As their magnitudes range from 5¼ to 7½, they could be handled even with the comparatively small instruments used in the field.

Each star was observed sixteen times, eight times at each culmination, half the time with the fixed circle east, and half the time with the instrument reversed. The ten close circumpolars which already form a part of AUWER'S A. G. C. system were employed in obtaining the constants of reduction; the clock-stars were chosen from a list selected by Dr. AUWERS; usually eight of the clock-stars were used each night.

Professor TUCKER gives a careful discussion of the possible errors affecting his observations, including those of the close circumpolars which were employed as fundamental; all of these quantities are fractions (generally small) of a second of arc. An important by-product of the investigation is, that the Poulkova refraction-tables do not accurately correspond to the meteorological conditions at Mt. Hamilton. The probable error of the final position of a star derived from sixteen observations is, in R. A., $\pm 0^s.005 \sec \delta$, and in Decl., $\pm 0''.08$. In this connection Professor TUCKER makes the following interesting statement: "As indicating how large a part the unavoidable errors in the reduction may play, the simultaneous observations of the transits of the two stars of the pair l_1 and l_2 of the list give an interesting illustration. Each star was observed completely, upon sixteen nights, and both transits are recorded. This gives thirty-two values of the mean difference at transit, $7^s.56$, with the probable error of one determination, $\pm 0^s.087$. The probable error of a transit is thus found to be $\pm 0^s.061$, which reduces to ± $0^s.001$ sec δ, for the mean of thirty-two observations."

Such accuracy plainly shows the excellent quality of the "seeing," as well as the skill of the observer.

ZODIACAL STARS.

In the summer of 1898 the positions of half a hundred zodiacal stars were obtained by request of Sir DAVID GILL, for use in his heliometer measures of the major planets. In the first seven months of 1900 these stars were reobserved, and about an equal number added. For the earlier observations the places of the thirteen fundamental stars were furnished by Dr. GILL. By means of eight of these fundamental stars a comparison of Dr. GILL's places with those of Dr. AUWERS was made. The mean difference in Right Ascension is $0^s.011$, and in Declination it is $0''.35$. In order to investigate the systematic error in Declination, Professor TUCKER compared the value of the latitude derived from the thirteen fundamental stars in Dr. GILL's list with the value obtained by observing circumpolars. The two results differ $0''.56$; if only the eight stars given by AUWERS are used, and his declinations are adopted for them, this discrepancy is reduced to $0''.27$.

For the observations of 1900, fourteen fundamental stars were selected by Dr. GILL, but he published no places for them. The places of six of them were therefore taken from the *Berliner Jahrbuch,* and Dr. AUWERS's corrections were applied to them. The eight stars which were not found in the *Jahrbuch* were specially observed, using AUWERS's corrected *B. J.* stars as fundamental. Ten of the fourteen are found in NEWCOMB's Fundamental Catalogue. The average difference between the coordinates adopted by Professor TUCKER and those given by NEWCOMB is $0^s.018$ in Right Ascension, and $0''.01$ in Declination. The probable errors of the places finally deduced for the zodiacal stars are for the annual results:—

$\pm 0^s.011$ in R. A.
and $\pm 0''.17$ in Decl.

Experiments with screens, to determine the correction to transits due to the magnitudes of the stars, gave the value of this as $-0^s.006$ per magnitude, faint stars being recorded later.

THE PIAZZI STARS.

All of the stars of Southern Declination found in PIAZZI'S Catalogue were given place in the working list, which thus embraced 3,088 stars. The observations were undertaken at the suggestion of Dr. H. S. DAVIS, who is engaged in a re-reduction of PIAZZI'S original observations. Two observations of each star were made, and several which were used as fundamental stars have naturally been observed a greater number of times. In all 7,600 observations (including circumpolars and nadirs) were made, on 146 nights. For 4,400 of the observations the circle-microscopes were read by Dr. R. T. CRAWFORD. When he assisted in this manner, the average number of observations per night was sixty-one; when Professor TUCKER was alone, the average number was forty-six.

The excellence of the meteorological conditions and of the construction of the observing-room is shown by the fact that ordinarily there is not a difference of one degree between the temperatures outside and inside the room when it is closed. Upon the best nights the temperature remains nearly constant, often changing less that a degree for several hours. The maximum change of barometric-reading during the four or five hours of an observing period was four hundredths of an inch. The care and skill of the observer are abundantly attested by the table of probable errors for those stars which were not fundamental. Since many of the observations were made at very low altitudes, where the images were poor, and the effects of irregular refraction much greater than the average, the observations were divided into five zones, each 10° in width. For stars between the equator and 30° south the probable error of the mean of two observations may be well represented by the expressions—

$$\pm 0^{s}.016 \sec \delta \text{ for R. A.}$$
$$\text{and } \pm 0''.23 \text{ for Decl.}$$

From 30° downward to 46°.8, which is the extreme southern limit in Declination, the error in Right Ascension increases a trifle, but that in Declination increases quite rapidly. Professor TUCKER has derived the following approximate expression for the probable error in declination:—

$$\pm [0''.15 + 0''.09 \, (\tan \text{Z. D.} - 1)]^{*}$$

---

* The reviewer has taken the liberty of inserting the [ ], which do not appear in the original.

At the southern limit this expression reaches the value ± 1″.0, when the star is but 6° above the horizon.

The places used for the fundamental stars were determined by an extended discussion, for the details of which the reader must refer to the volume itself. The following direct quotations will give an idea of the problem by which Professor TUCKER was confronted and his solution of it:—

> "With the use of the Poulkova Refractions we should obtain the Latitude 37° 20′ 25″.39 from the Circumpolar stars observed at both culminations, during this series. The observations of Latitude from the *B. J.* Southern stars would indicate a mean correction of —0″.16 for its system of Declinations, down to —31°. The Latitude observations of the list of 303 would indicate a correction of —0″.56 for its Declination system down to —25°. Employing NEWCOMB's Declinations down to —31°, the indicated correction would be —0″.68. Employing the Declinations of Boss, for the Standard stars —20° to —31°, the correction to his system would be —0″.72. Similarly for AUWERS's Southern Fundamental Catalogue, —20° to —31°, the correction would be —0″.92.
>
> "The evidence points strongly to a decrease in the Poulkova Refractions, for this place, if the standard systems above enumerated are to be reconciled with the observations made here. The differences increase proportionally, as Declinations, below the limits above, are used for the deviations of Latitude."
>
> "As explained in full detail, earlier, the observations have been reduced with such of the Southern Piazzi stars as Fundamental, as are included in AUWERS's corrected *B. J.* and 303, the system of the last-named having been adopted. In extending the Declinations beyond the limits of the Fundamental stars, comparisons with AUWERS, NEWCOMB, and Boss have been made, for the determination of the corrections to the Poulkova Refractions, employed throughout."

The observations are grouped in two tabular exhibits. In the first there are given for each star the separate determinations of Right Ascension and Declination, and the correction to the latter derived by diminishing the Poulkova Refractions. The second exhibit is in the ordinary catalogue form, the refraction correction just mentioned having been applied to each Declination.

REFERENCE-STARS FOR *EROS.*

These observations were made to assist in determining the parallax of *Eros* at its opposition in 1900. There were 677 stars in all, which were observed on fifty-four nights, two determinations of the place of each star being made. The probable error of the final place of a star was ± 0″.20 in each coordinate.

MISCELLANEOUS OBSERVATIONS.

These embrace determinations of the places of forty-nine comparison-stars, for other observers or orbit-computers, of twenty proper-motion stars for Professor J. G. PORTER, of *Eros*, of *Nova Persei*, and of comets *b* 1897 and *c* 1898.

THE INSTRUMENTAL CONSTANTS.

Under this caption are given the values of the constants during the four years and a half covered by the observations in the volume. The twenty-eight determinations of the flexure correction vary from — 0″.31 to + 0″.21, the mean of all being only — 0″.045. The nadir-readings seem to depend a little upon variations of temperature. The changes of collimation are very small, and its average value is close to zero. The total range of the azimuth-error was $0^s.6$, and it varied somewhat irregularly. The level-error changed in general slowly and smoothly, having an average value of about $0^s.5$.

Professor TUCKER received assistance from time to time in reading the circle-microscopes, and in reducing the observations, from Messrs. AITKEN, CODDINGTON, CRAWFORD, CURTISS, DALL, PALMER, and STEBBINS, the work of each of whom is particularly described. It appears that, had he received no aid, he would have made and reduced about 2,500 observations a year.

One closes this volume of the *Lick Observatory Publications* with a high admiration for the energy, precision, and painstaking of the observer, and with a feeling of satisfaction that he uses an instrument so perfect in a location so favorable. The results speak for themselves, and are a distinct credit to American astronomy.

HERBERT A. HOWE.

CHAMBERLIN OBSERVATORY, DENVER, COLO., November, 1903.

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD IN THE ROOMS OF THE SOCIETY, NOVEMBER 28, 1903, AT 7:30 P. M.

President **VON GELDERN** presided. A quorum was present. The minutes of the last meeting were approved.

The following members were duly elected:—

LIST OF MEMBERS ELECTED NOVEMBER 28, 1903.

Mr. **SEBASTIAN ALBRECHT**	Lick Observatory, Mt. Hamilton, Cal.
Miss **EDITH ALLYNE**	N. W. Cor. Gough and Green Sts., S. F. Cal.
Dr. **A. J. ATKINS**	494 and 496 Parrott Building, S. F., Cal.
Mr. **ELWYN B. GOULD**	808 Juniper St., San Diego, Cal.
Dr. **B. L. NEWKIRK**	2218 Union St., Berkeley, Cal.
Dr. **HARRY EAST MILLER**	331 Pine St., S. F. Cal.
Mr. **C. M. ST. JOHN**	U. S. Custom House, S. F., Cal.
Dr. **OMAR A. TURNEY**	U. S. G. S., Livingstone, Gila Co., Arizona.
Dr. **W. VILLIGER**	Jena, Germany.

The Librarian reported that the manuscript catalogue of the bound books in the Library has been completed, at a cost of $50, as authorized by the resolution adopted at the meeting of November 29, 1902. The report was adopted and filed.

It was, upon motion,

Resolved, That the next regular meeting of the Society (January 30, 1904) be held at the Students' Observatory of the University of California, at Berkeley.

Adjourned.

MINUTES OF THE MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD IN THE LECTURE HALL OF THE CALIFORNIA ACADEMY OF SCIENCES, NOVEMBER 28, 1903, AT 8 O'CLOCK, P. M.

The meeting was called to order by President **VON GELDERN**. A quorum was present. The minutes of the last meeting were approved. The Secretary read the names of new members elected.

The following papers were presented:—

The Ring Nebula in *Lyra*, by Dr. B. L. **NEWKIRK**.
The Great Sunspot of October, 1903, by Miss R. **O'HALLORAN**.
Planetary Phenomena for January and February, 1904, by Prof. M. **MCNEILL**.

The Chairman then introduced the lecturer of the evening, Dr. B. L. **NEWKIRK**, who read his paper on the Ring Nebula in *Lyra*, and exhibited a number of slides of the principal nebulæ.

The meeting then adjourned.

OFFICERS OF THE SOCIETY.

Mr. OTTO VON GELDERN	*President*
Mr. S. D. TOWNLEY	*First Vice-President*
Mr. W. W. CAMPBELL	*Second Vice-President*
Mr. CHAS. S. CUSHING	*Third Vice-President*
Mr. R. G. AITKEN Mr. F. R. ZIEL	*Secretaries*
Mr. F. R. ZIEL	*Treasurer*

Board of Directors—Messrs AITKEN, BURCKHALTER, CAMPBELL, CUSHING, LEUSCHNER, MOLERA, CROCKER, VON GELDERN, PIERSON, TOWNLEY, ZIEL.

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Committee on Publication—Messrs. AITKEN, SCHLESINGER, TOWNLEY.

Library Committee—Mr. TOWNLEY (*Librarian*), Mr. RICHARDSON, Miss O'HALLORAN.

Committee on the Comet-Medal—Messrs. CAMPBELL (*ex-officio*), PIERSON, BURCKHALTER.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. RUTHVEN W. PIKE.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. FELIPE VALLE.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

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